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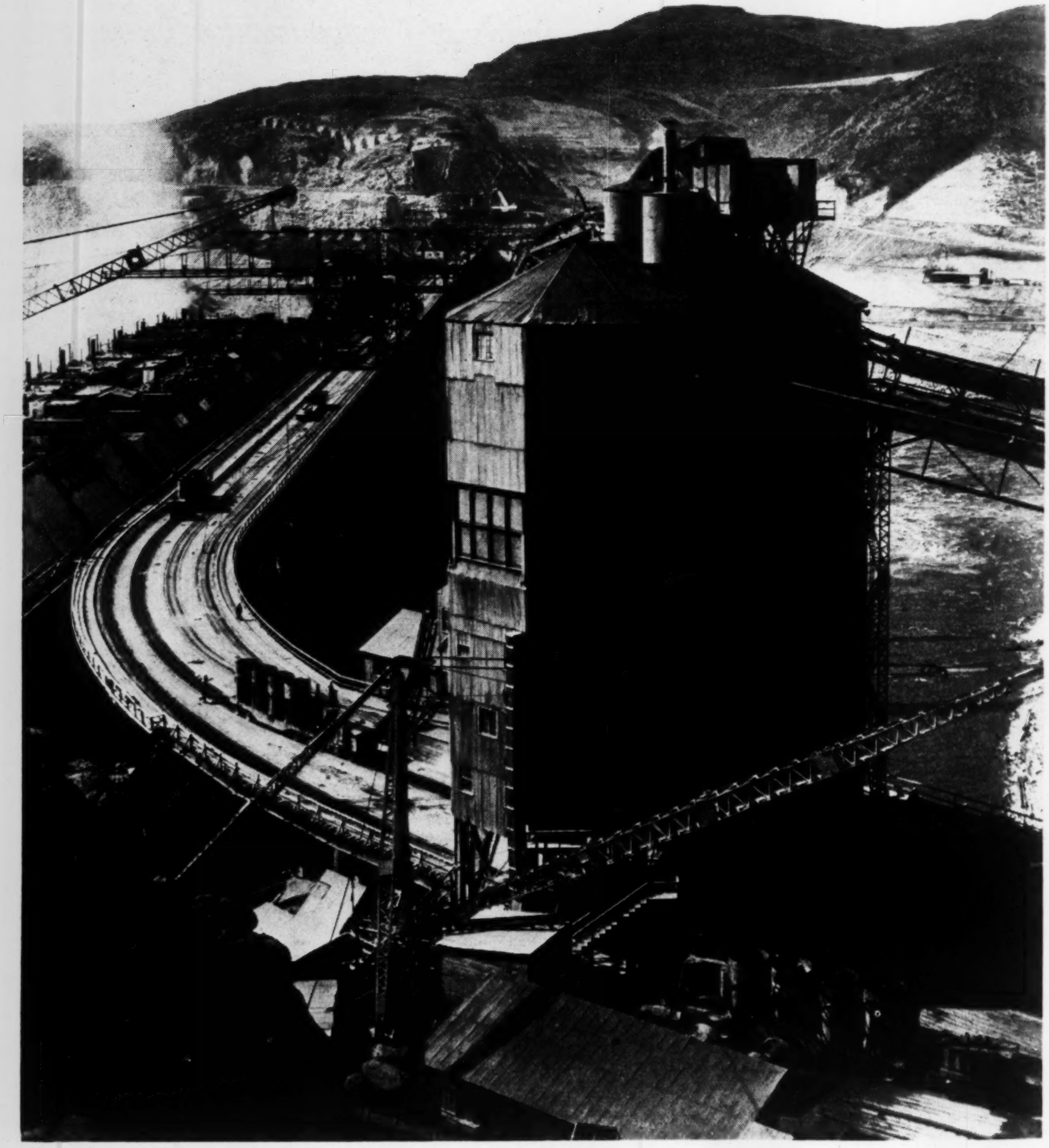

Construction Work at Grand Coulee Dam

(An All-Day Excursion to the Dam Is Scheduled for the 1940 Fall Meeting, The American Society of Mechanical Engineers, Spokane, Wash., Sept. 3–6, 1940. See pages 567 and 568 of this issue.)

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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

Commencement

TO EVERY college man the word commencement has a special significance. As an undergraduate he looked forward to it as an end, rather than a beginning, the end of his boyhood and the period of preparation for life. Only the class-day orator reminded him of the "challenge," the "opportunity," that lay ahead. The graduate looks on commencement as the day on which to return once more to the shaded quadrangles so remote in time and space from the world in which he lives.

The realities that follow commencement are significant too, for they put men to the test. The zestful atmosphere of the college dormitory gives way to the stark loneliness of a hall bedroom, the easy freedom of the campus to the strict confinement of shop and office, the good-natured rivalry of the playing field to the harsh competition of industrial life. New pleasures are found; more vital goals are sought; the boy grows into the man; burdens increase as responsibilities are assumed; and the result is a full and useful life, or an empty one marked with lost illusions and failures.

The American people were face to face with their commencement in May and June of 1940. For them one epoch ended and another began. The easy days gave way to hard ones yet to come. The period of maturity arrived, with its test of character. The nation, its citizens, and its institutions suddenly awakened to the fact that they were in the grip of powerful world forces whose effects they could not escape.

A distinctly different way of life is henceforth indicated for America and decisions as to how adjustments to it may be found must be made. The challenge of commencement has been sounded and the realities of life after commencement are about to be faced. Engineering societies must re-examine their purposes and revise their programs to contribute to the common goal—a better and safer world. They will find many immediate projects to which to give their attention, but they will also discover that much of the work of the past will be put to use.

Cutting Data Being Used

FACED with the problem of preparing for national defense, American industry finds, as indeed it found with increasing peacetime production, that its supply of skilled workers is woefully inadequate. The reasons are numerous and need not be reviewed; the fact is sufficiently important to call for action.

So long as private industry seemed to be principally concerned with the recruitment of skilled workers, the nation appeared content to let the situation drift, but now that national defense has become the most absorbing task before the United States, it is not surprising to find the Administration directing its attention toward training for industrial employment.

Before many weeks have passed the demand for skilled workers will have become so acute that every helpful device will be seized upon. In one small sector, fortunately, the activities of the Committee on Cutting of Metals of The American Society of Mechanical Engineers have provided what is proving a real aid to machine-shop operators who must not only get the most there is out of their cutting tools but also must do so with green hands. The "Manual on Cutting of Metals," recently published by the A.S.M.E. under the auspices of this committee, gives aid in this field.

Already at least one manufacturer has found that the data contained in the Manual has increased his production and has made it possible for him to obtain from inexperienced apprentices working at rough-turning operations removal of metal at greater rates than the ordinary skilled worker, relying on his own judgment, customarily accomplishes. This is one of those cases where "a little knowledge is a dangerous thing." Apprentices, having no personal judgment on which to base their choices of speeds and feeds, must, perforce, rely upon the directions given them by their foremen and instructors. For many reasons, experienced machinists may prefer to stack their own judgments against the accumulation of scientifically determined speeds and feeds presented in the Manual, and thus defeat the purpose of securing increased production.

It is a safe prediction that the Manual will become an important factor in national preparedness by increasing production in metal-cutting operations. Members of The American Society of Mechanical Engineers will take satisfaction in knowing that the work of the Committee during industrial hard times is coming into its own when greatly needed in a national emergency.

Industrial Uses of Photography

ONE has only to look back over sixty years of issues of the A.S.M.E. Transactions to note how extensive the use of photography in engineering has become. In the early volumes the commercial artist and engraver were called upon to provide drawings; later, photographs, mostly of objects and scenes, gave clearer meaning to the descriptions of the author. Photography as a useful engineering tool, combined with the microscope, next made it possible to obtain records of the structures of metals, and the camera proved a valuable aid in the study of stresses by the technique of photoelasticity.

Industrial uses of the motion-picture camera further extended the photographic techniques available to engineers, as, for example, the motion-study analysis of the Gilbreths and investigations of rapidly moving objects by means of the ultra-high-speed camera, of which Baron Shiba's was a much discussed example. Motion pictures in color showing combustion phenomena in furnaces have been shown at A.S.M.E. meetings.

Then came the stroboscope, which made possible the apparent arresting of a rapidly moving object, like a fan or a flywheel, and combinations of several of these techniques, such as photoelastic examination of models, under stroboscopic conditions, subjected to stresses applied by centrifugal force. Many other examples could be added to this partial list.

Elsewhere in this issue appears an illustrated article explaining how the stroboscopic technique of Edgerton has been applied to the study of rapidly moving parts of looms. "Swifter than the weaver's shuttle" has been a phrase used for centuries to describe motions much too rapid for the eye to follow. Yet Messrs. Sepavich and Palmer, using the modern aids of photography, have succeeded in photographing the shuttle in flight with definition as sharp as though it were at rest. What further developments are under way the future will disclose, but progress already made is sufficient to suggest the great variety of machines and problems in stresses and kinematics that can be fruitfully studied by photographic aids. Apparently we are just on the threshhold of a rapidly developing field of analysis.

Friction and Surface Finish

ONE of the finest technical conferences within the field of mechanical engineering held in recent years was conducted at the Massachusetts Institute of Technology, June 5 to 7, 1940. Three days were devoted to a series of papers on friction and surface finish. With a registration of about 175, the conference offered a carefully planned program of papers and discussions that had no dull moments and served to bring together experts from many fields of research, production, and operations, whose studies and interests converged on these important subjects. Although succeeding speakers lightheartedly asserted that their discussions were contributions to the confusion which exists in respect to the layman's understanding of the subject, it was nonetheless apparent that the concentration of attack on it from all sides was resulting in real progress.

The contributions to this remarkable conference represented a variety of specialized interests. Physicists, metallurgists, chemists, lubrication experts, production men from the machine-tool, automobile, and airplane-engine industries, representatives of research laboratories, universities, and industry threw into the conference their special knowledge for the good of all, and created in the mind of the lay observer the impression that science and industry are forging ahead together in fields that, a few years ago, would have been considered too controversial, too theoretical, too complex for profitable common study.

A brief survey of the program will convey an inadequate impression of the subject matter covered. A. F. Underwood, of the General Motors Research Laboratories, opened the Conference with a discussion of some general aspects of rubbing surfaces, and was followed by John Wulff, of M.I.T., who spoke on the metallurgy of surface finish, and D. A. Wallace, of the Chrysler Corporation, who described the preparation of smooth surfaces, with particular emphasis on "superfinish."

Stewart Way, of the Westinghouse Research Laboratories; discussed methods of describing and observing metal surfaces; and Hans Ernst and M. Eugene Merchant, of the Cincinnati Milling Machine Company, basing their contribution on results that originated with researches in the cutting of metals, talked about surface friction of clean metals and presented a theory of friction. The complex subject of boundary lubrication was introduced by G. B. Karelitz, of Columbia University.

Four papers provided abundant material for the third day's session. Otto Beeck, of the Shell Development Company, spoke on the mechanism of boundary lubrication, and F. C. Linn, of the General Electric Company, on thin-film lubrication. Some features of laboratory wear and friction testing were discussed by R. W. Dayton, of the Battelle Memorial Institute. As a concluding summary, O. R. Schurig, of the General Electric Company, reviewed the principal points brought out by the scheduled speakers and the discussers, and pointed out the difficulty that exists when engineers attempt to set up some simple and generalized description of a surface which may in some cases be used with a lubricant, in others dry, and in others for joints of various kinds.

The general scheme of the Conference provided prepared papers for presentation at the morning session, followed at the afternoon sessions by prepared discussions, in many cases as elaborate as the papers themselves, and informal questions and comments from the floor. The promise was made that the complete proceedings of the Conference would be published, thus making available for reference and study an extraordinary amount of important, original, and varied material.

With the excellent start made by the M.I.T. Conference, it is to be hoped that later conferences will coordinate and make available to designers, production men, operators, and students of the subject an increasing volume of authoritative material that should be of tremendous practical and scientific value. Here is impressive evidence, once more, of the fecund union of engineering practice and scientific research and theory that is extending engineering achievements at a rapid pace. Coming at a time when every scrap of information and every means of increasing production and of decreasing friction, wear, and waste are important in the national defense effort, the Conference gave unusual promise of developing further valuable information, and had a truly national as well as engineering significance.

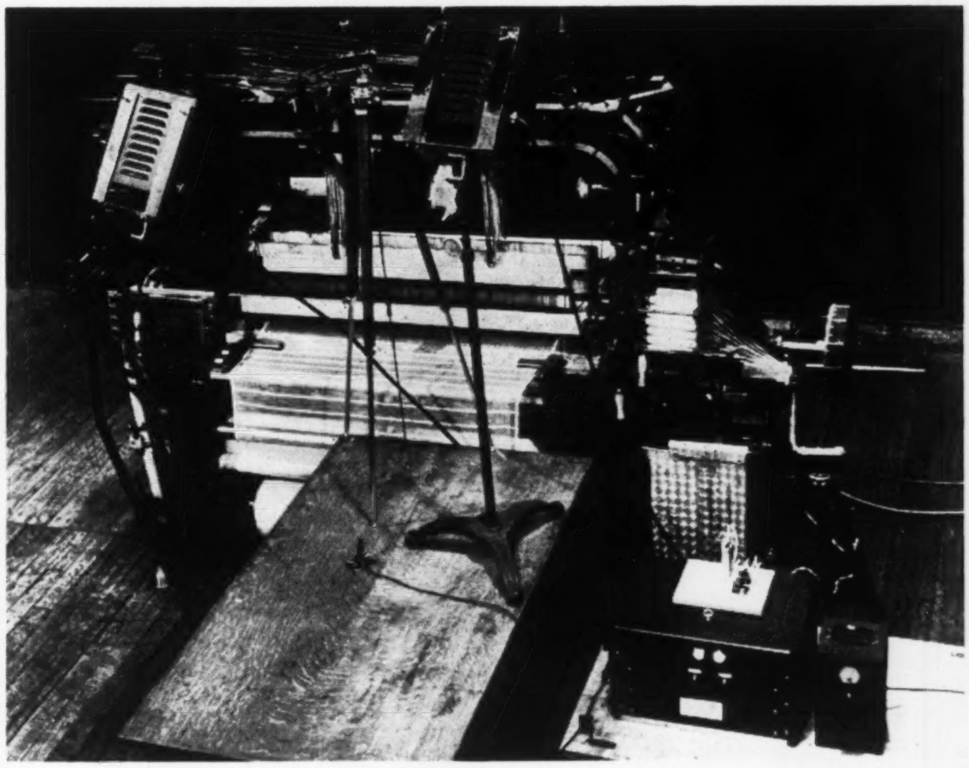

FIG. 1 TYPICAL TEST SETUP USED IN STUDY OF SHUTTLE FLIGHT

(Speed of loom, corresponding to total passages across loom is approximately 162 rpm. On each passage, shuttle covers distance of $77^1/_2$ in. and attains maximum velocity of approximately 45 fps, or about 30 mph.)

HIGH-SPEED PHOTOGRAPHY *and the Study of* RAPID MACHINE MOTIONS

By VICTOR SEPAVICH AND ALBERT PALMER

CROMPTON & KNOWLES LOOM WORKS, WORCESTER, MASS.

FOR analytical purposes, mechanisms may be classified in three groups from the standpoint of the means by which they are driven or controlled: First, those that are positively connected with the source of power; second, those that are driven in a semipositive manner; and third, those that, at some point in their cycle of operation, are freely moving bodies.

In the first group may be placed mechanisms which are driven directly from the source of power by shafting, gears, a crank, or a linkage. Included also are mechanisms which are actuated by a positive cam of the path type in which no springs are required to hold the cam follower on the cam. All these mechanisms have a motion which is positively dependent upon the source of power. Their timing and their displacement are functions of the motivating body and are influenced by the physical characteristics of the means by which motion is transmitted from the parent mechanism to the dependent mechanism.

The second group of mechanisms includes those driven by some means in which there are variable elements such as slippage, elasticity, or time delay. Here should be placed mechanisms which are actuated through clutches, compressed air, hydraulic means, electrical means, or face cams, where the cam follower is under the control of a spring which keeps it on the cam.

The third group embraces mechanisms which, for a substantial part of their cycle of operation, are not subject to any positive or semipositive control. These mechanisms may depend upon gravity or upon kinetic energy imparted to them from some source which subsequently is disconnected. Examples involving the first principle are various types of conveyers and drop hammers. Examples involving the latter are guns, the shuttle-throwing mechanism of looms, and the inertia starters which are used for starting engines.

TYPES OF PROBLEMS INVOLVED

While the problems that are presented to designers are similar in all mechanisms, they have certain characteristics which are related closely to the group into which each mechanism falls. In the first group, for instance, although the elements of time

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and space theoretically are under definite control, they may be affected by physical changes in the component parts of the drive. At high speeds, interference and incorrect timing may result from the distortion of parts. These changes in physical shape generally are caused by stresses which are introduced or from the clearances that are provided. Sometimes a machine, which operates perfectly when turned over slowly, will cause trouble when it is run at its normal speed or under its normal load. The materials of which the drive is constructed may expand or contract under stress or under changes in temperature or humidity. Again, the operation of the mechanism may cause all the clearances to be additive in one direction so that, under conditions of close timing or limited space, interference of parts will result.

The semipositively driven mechanisms exaggerate these problems. Some types of clutches alter the time-and-space relationship because of slippage. Drives involving air, steam, and rubber or other similar material are affected by the elasticity of the power-transmission medium. Electrically or hydraulically driven machine units similarly are subject to time delay because of time lag in solenoids or because of the time required to build up pressure. Friction in the medium itself or in the means by which the medium is conducted from the driving to the driven mechanism also has its influence.

In some types of mechanisms where a face cam is used, springs are necessary to hold the cam follower on the cam. If these springs are not suitably designed, the cam follower at some point in the cycle of operation may fail to remain in contact with the cam, thus introducing an element of uncertainty in the motion of the driven mechanism. Energy-absorbing devices likewise may be uncertain. Because of the difficulty of calculating loads or because of unexpected characteristics in the energy-absorbing material itself, the time-and-space relationship may be affected to such a degree that unexpected results are obtained.

In the third general group of mechanisms where, during a part of the cycle, some element of the mechanism is neither partially nor wholly controlled by the main source of power, the matter of time and space is not predictable with any great degree of exactness. For instance, the flight of the shuttle in a loom or the movement of a drop hammer is subject to many influences. Such objects as these start with a known velocity and a calculable amount of stored energy. Their movement, however, is dependent upon many influences which cannot be computed with accuracy. They are subject to mechanical friction and to air resistance. These items, particularly in the case of the shuttle, are influenced not only by temperature and humidity, but also by the changing velocity of the shuttle. Thus, the designer must deal with unknown quantities and must base much of his work on assumptions and empirical methods.

METHODS OF INVESTIGATION

Problems dealing with positively controlled motion can be solved by the theories of mechanics. They can be analyzed by graphical and mathematical processes. Physical tests can be made through the use of models or actual machines. Generally speaking, by a combination of these processes, difficulties with machine operation can be overcome.

In mechanisms where the control of time and space is semipositive, problems can be solved partially by graphical and mathematical methods. Frequently, however, more extensive experimental work is necessary than is the case with mechanisms which have a positive drive. In such instances, measurements of time and space generally are vital and involve more intricate methods than where positively driven machinery is concerned. In the latter case, time and space generally can be measured in terms of the original source of power, the speed and motion of which is known. But, in cases where the connection between the original machine and the driven mechanism is not positive, time and space must be measured in terms of some independent device. Time measurements, for example, may be either mechanical or electrical. They may be some form of pendulum or tuning fork, or an electrical means such as a synchronous motor operating at a known speed or a generator or other source of power producing impulses of a known frequency.

The measurements of unknown time and space elements in terms of a known source become even more necessary in mechanisms where there is no connection between the driving and the driven unit. Here the problem becomes involved because any mechanical contact with the moving body may alter its motion and cause the investigator to reach incorrect conclusions. A case in point is the shuttle of a loom. Virtually it is a projectile. Any attempt to measure its velocity by means of mechanical contact may alter its flight.

Experimental methods involving physical contact with a freely moving body like a shuttle are difficult to handle. The opportunity for introducing contacts is limited by the physical characteristics of the machine itself and by the fact that the course of the shuttle is not always exactly the same. Thus, apparatus for recording the movement of the shuttle on the measuring device must have no physical contact with the shuttle.

To span the gap between the object to be measured and the measuring device, without mechanical contact, is a difficult laboratory problem, particularly in view of the speed involved. The photoelectric cell may appear to be the answer. This apparatus, however, is inadequate because of the time lag introduced by the electrical equipment, which indicates on the measuring device the interruption of the light beam by the object to be measured. Doubtless suitable photoelectric devices could be devised but, for the average industrial plant, the technique of modern photography offers a much more satisfactory method for measuring time and space with no connection or contact between the body to be studied and the measuring apparatus.

PHOTOGRAPHIC MEANS AVAILABLE

Photographic measurements of time can be made by some form of controlled shutter, by placing a time-indicating device in the field of the picture, or by having a light source that flashes at known intervals. The method employed depends upon the type of equipment which is available.

Generally speaking, single-exposure cameras are useful only for instantaneous single views of the mechanism that is being studied, unless some means is devised for taking multiple exposures on one plate through some form of shutter control operated by the machine that is being photographed. An arrangement of this kind is not altogether practical because of the difficulty of actuating the camera, often remotely situated with respect to the part of the machine from which motion for operating the shutter can be obtained. A further difficulty in a contrivance of this sort is the time lag introduced by lost motion in the actuating parts or by delay in solenoids that are used.

Even for single-exposure still pictures, modern cameras have their limitations. Despite recent advances in films, shutters, and lighting, the photographing of high-speed machinery is not satisfactory. With a shutter speed as fast as 1/1250 sec, a fast-moving object such as the shuttle of a loom, Fig. 2, cannot be "stopped." A picture which is taken at right angles to the path of motion has poor definition, at least as compared with pictures taken by other methods.

The measuring of displacement by means of a single-exposure still camera is not accurate. The time of camera shutters is only

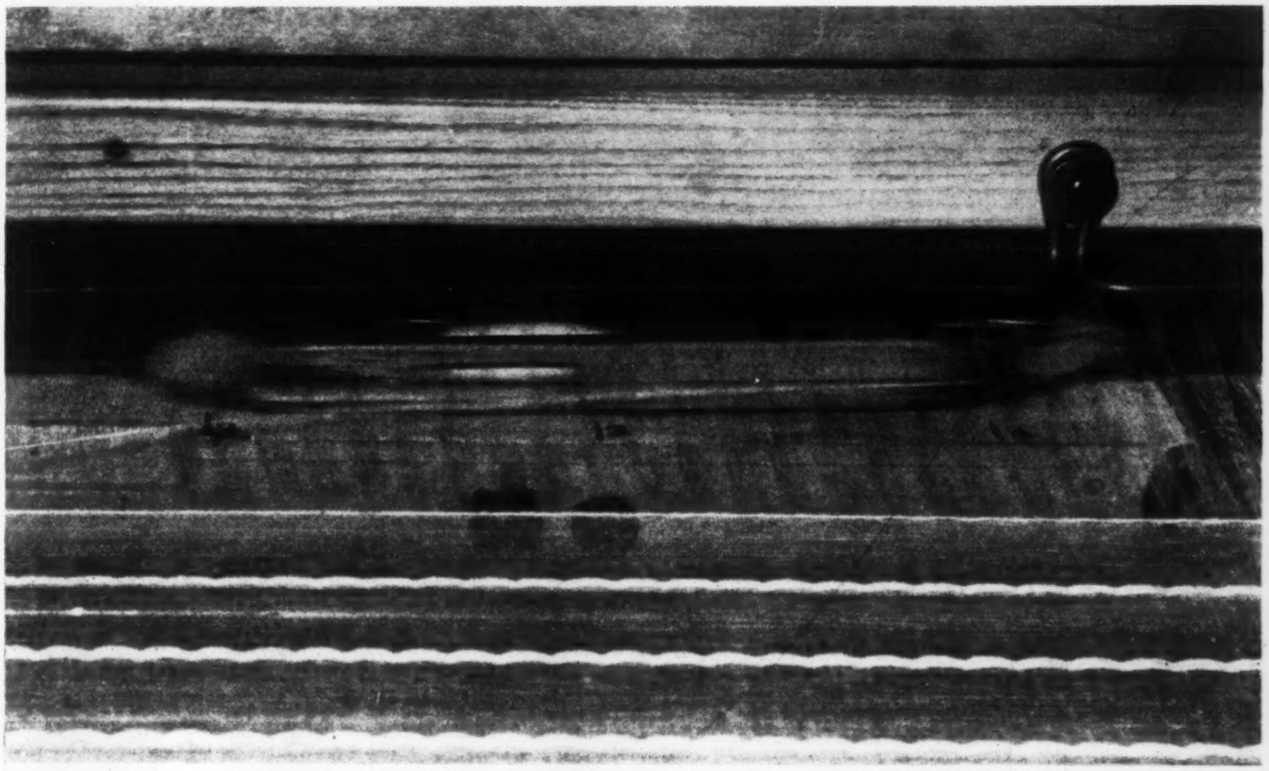

FIG. 2 SHUTTLE PHOTOGRAPHED BY HIGH-GRADE STILL CAMERA

(Shutter setting $^1/_{1250}$ sec; this speed not great enough to stop shuttle completely since during exposure it moved approximately $^1/_2$ in. Shutter had to be started fully 20 crankshaft deg ahead of desired shuttle position in order to place it in full view of camera.)

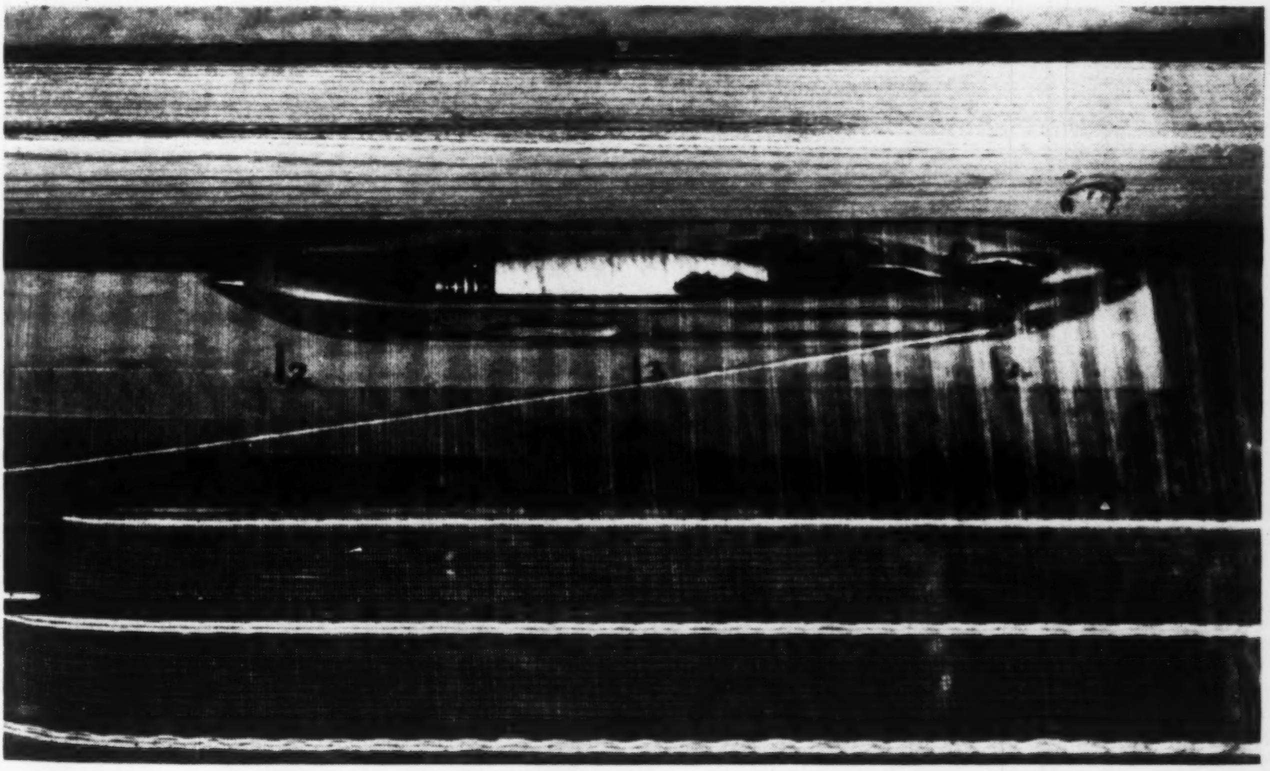

FIG. 3 VIEW OF SHUTTLE SHOWN IN FIG. 2 TAKEN WITH AID OF STROBOSCOPE

(Duration of flash 0.00001 sec. With this extremely short duration of exposure, the shuttle is "stopped" in its tracks.)

approximate. Recent investigations show that shutter speeds, on the best cameras, sometimes are inaccurate by as much as 25 per cent. Naturally, where an error as large as this occurs, the camera shutter cannot be relied upon as a timing device for analytical studies of motions.

Because of the difficulty of taking measurements with a single-exposure still camera, motion pictures are valuable. With an ordinary commercial motion-picture camera, time and space measurements can be made by placing suitable devices in the field of the picture. Increments of displacement can be marked on stationary parts of the machine so that the motion of moving parts can be determined with reference to the scale that is adopted. Similarly, a time-recording device can be photographed. It can consist, for example, of a synchronous motor with a disk mounted on its shaft, provided with markings from which angular movement and time can be computed when the developed film is turned over frame by frame.

Although commercial moving-picture cameras are suitable for low-speed work, they become inadequate where rapidly operating mechanisms are involved. There are, of course, commercial cameras which are capable of taking slow-motion pictures. These, however, are limited to a maximum speed of approximately 200 frames per sec. Up to this rate of speed the results are reasonably satisfactory, barring the fact that film is wasted in bringing the camera up to speed and in stopping it. Sometimes difficulty is encountered at these high speeds with the film-driving mechanism of the camera. If the camera jams because of this intermittent motion, the film may be spoiled. There is another difficulty which, though not insurmountable, is the great amount of artificial light needed in photographing a comparatively small area with this type of equipment.

The endeavors to overcome the limitations of the commercial slow-motion camera have resulted in various types of ultra-slow-motion equipment. One of these is a camera which has no shutter and which causes the film to move continuously rather than intermittently. The framing of the picture is accomplished by means of a rotating optical system which keeps the movement of the image synchronized with the movement of the film. The camera includes an accurate timing device consisting of a synchronized clock driven from the impulses of a tuning fork. It can take pictures at speeds up to 2500 frames per sec. The film along one margin carries a time record that can be read to within 0.001 sec.

Although slow-motion pictures are very satisfactory in the analysis of rapid motions, they are expensive and involve either the ownership of very costly apparatus or the services of one of the several excellent concerns which are engaged in this type of photography. For special studies, the expense is warranted but for routine investigation in the research and development departments of an industrial plant, it is not justified. A more economical method for making time and space measurements is desirable so that observations can be made at short notice and as often as desired.

The most useful and satisfactory tool of this nature that has been devised is the power stroboscope, which was developed by Prof. Harold E. Edgerton and his associates at the Massachusetts Institute of Technology. With this instrument and almost any type of still camera, surprising results can be obtained, provided the work can be done in subdued light. Pictures are taken as they would be with a photoflash bulb. The camera shutter is held open and a very powerful light is flashed. In comparison, however, with a photoflash bulb, the Edgerton apparatus gives an exposure which is approximately 2000 times as fast. In other words, it is an exposure of approximately 0.00001 sec, Fig. 3.

Despite the shortness of the exposure, excellent pictures can be obtained with a comparatively small lens opening. The actinic value of the light is extremely high and of an intensity which has been determined by Professor Edgerton to be equal to that of approximately 2,000,000 watts of incandescent light. The tube used in producing this tremendous burst of light, more intense than ordinary sunlight, is specially constructed and is filled with two very rare gases, xenon and krypton.

Without going into the intricacies of the electrical system by which this light is produced, the uses for this apparatus can be described. The light can be controlled either from the machine that is being studied or from some independent source. If a series of individual pictures showing the operation of a machine is desired, the light can be driven from a commutator placed upon some part of the machine. By advancing or retarding the contacts of the commutator with respect to the part of the machine to which it is attached, a series of views can be taken. Thus, the action of a mechanism can be traced step by step throughout its entire cycle of operation.

For observations involving simultaneous measurements of displacement and time, the stroboscope can be driven from an independent instrument such as the Strobotac or a synchronously driven commutator. Multiple exposures can be made on a single film. Knowing the time between the flashes and having in the field of the picture suitable scales against which to refer the motion of the subject, velocity and acceleration computations are made very readily.

In using the multiflash arrangement, a commutator driven by the mechanism to be photographed sometimes is useful. With it the flashing can be limited to any definite period, thus avoiding the confusion which might result were the light allowed to flash continuously. The camera shutter can be opened manually and a switch can be closed. The commutator then automatically causes a light to flash at a predetermined rate of speed over the interval which is to be studied. The ease with which the apparatus can be synchronized with the machine and the accuracy with which it can be calibrated make it readily adaptable to all kinds of work.

APPLIED STROBOSCOPY

Experience with the various forms of photographic equipment which have been enumerated has shown that the Edgerton power stroboscope is particularly valuable in the development of textile machinery. Until this apparatus was available, the movement of shuttles in looms could not be studied without resorting to the expense of slow-motion pictures. Now, however, shuttles that are moving back and forth across the loom 180 times per min at an average speed of approximately 45 ft per sec can be subjected to the most minute observation. By means of single-exposure stills, its behavior can be examined during the operating cycle of the machine. By multiexposure still pictures, the velocity and acceleration of the shuttle can be determined in relation to the timing of other parts of the loom.

Not only has the power stroboscope accurately determined the characteristics of shuttle travel, but also it has made possible the study of various other rapidly moving mechanisms on looms such as the magazine, the center stop motion, and the jumper motion. With its aid, surges in springs during compression and expansion, torsional deflection in driving shafts, and vibration in various parts of the loom have been observed.

Although good results can be obtained by an experienced operator, the perfection of this type of photography depends upon the technique of handling the stroboscope, cameras, color combinations, films, and development and printing processes. The best work is done in a darkened room. The correct diffusion of the light from the stroboscope lamp is important. The flash is so intense that it will be concentrated within a small area unless opalescent glass is placed over the tube or a diffusing

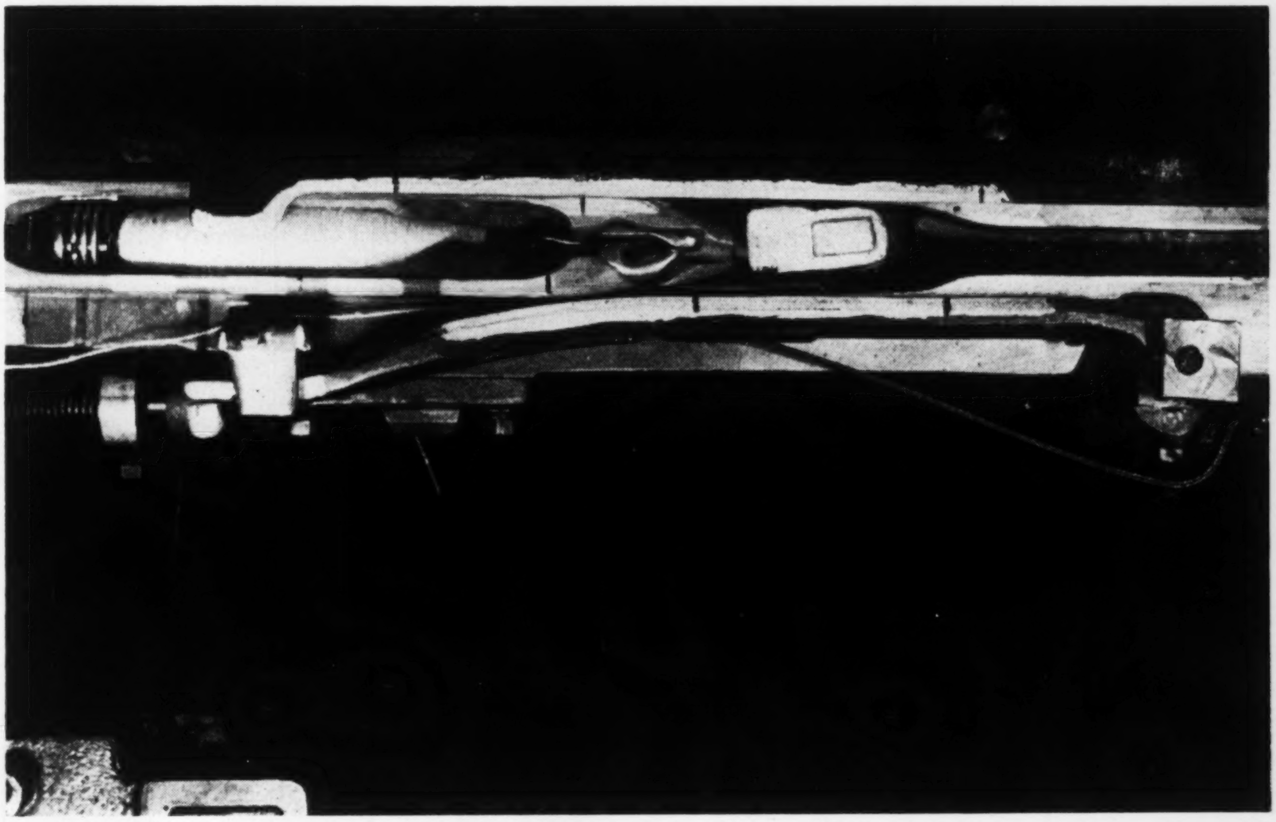

FIG. 4 SHUTTLE "CAUGHT" AT START OF TRAVEL ACROSS LOOM

(Photographs such as this allow studies to be made of filling, shuttle, and picker at this important instant of shuttle acceleration period.)

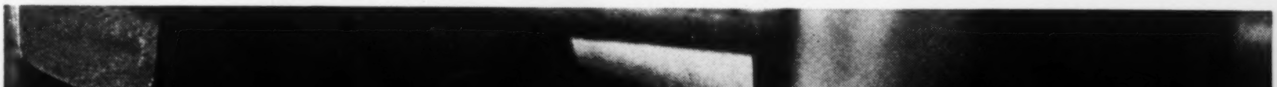

FIG. 5 BOBBIN IN PROCESS OF BEING TRANSFERRED IN LOOM RUNNING AT APPROXIMATELY 172 RPM

(Bobbin transfer had to occur without stopping loom. At particular instant shown, new bobbin is moving at a speed of 30 fps, approx.)

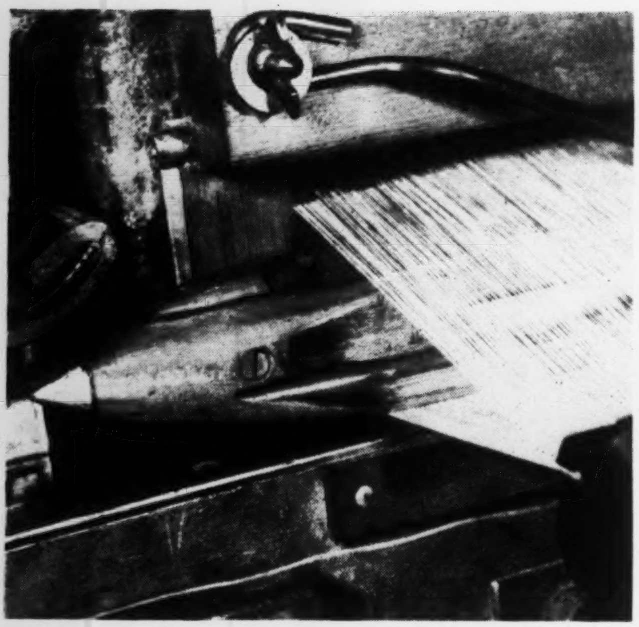

FIG. 6 ANOTHER TYPICAL EXAMPLE OF USE OF HIGH-SPEED PHOTOGRAPHY IN STUDYING LOOM OPERATIONS

(In this view, shuttle is coming toward observer at a velocity of approximately 50 fps. With aid of high-speed photography, any interference between warp threads and shuttle can be detected.)

lens is placed in front of the lamp. By means of this sort, the usable area of the light can be increased greatly.

The painting of objects to be photographed is important. For instance, where dials for time determination are used in the field of the picture, a flat-black background with white figures gives the most readable pictures. The same color scheme must be used where multiple exposures are made on a single film for velocity studies.

The lens opening of the camera depends upon the number of lamps, the distance of the lamps from the object to be photographed, the darkness of the room in which the work is being done, and the number of exposures that are to be made on one negative. With two lamps at a distance of 2 to 3 ft, the lens can be stopped to *f*-16 or *f*-22. With two lamps at 4 to 5 ft, *f*-11 is satisfactory. With one lamp placed 3 to 4 ft from the object, *f*-5.6 to *f*-8 will give good results. Where multiflash exposures are made on a single negative with one lamp at a distance of 2 ft from the object, the lens should be opened to *f*-4, provided the number of exposures is not more than 10. Where the number of exposures is increased, the lens must be stopped down. For instance, if 100 exposures are to appear on the negative, the lens opening should be adjusted to *f*-6.3. This decrease in the amount of lens opening is necessary because the repeated exposure of the film eats through the emulsion and destroys the contrast. If a black disk with a white line on it is photographed by the multiexposure method and if the lens opening is too wide, the background will be so light that the various positions of the white line cannot be determined accurately.

The choice of the camera depends upon the lenses with which it is equipped and upon the type of work that is to be done; also, upon the type of shutter. A camera with extension bellows for close-range work is advisable. With it extreme enlargement becomes unnecessary; consequently, the quality of the prints is much better than it would be with a camera which cannot be placed close to the object. A ground-glass focusing arrangement is advantageous. A camera in which cut films or film packs can be used is preferable to one requiring roll film. With it results can be checked without wasting time or film.

Camera shutters are important. The quick action of the Compur shutter makes it preferable to a focal-plane shutter. In the Compur shutter there is no time lag when it is being operated on "bulb." With it the operator can synchronize the opening of the shutter with the operation of the stroboscope.

The choice of film is a matter that merits consideration. Many high-grade high-speed films of the orthochromatic or the panchromatic type are available. A film like Eastman's Super XX developed in Eastman's DK-60A developer gives clear and brilliant negatives when exposed under the conditions previously outlined. This combination enables the exposure to be made with a relatively small lens opening and the film to be developed in a relatively short time with a minimum of grain structure. Doubtless, other combinations of film and developer will give similar results.

STROBOSCOPIC SLOW-MOTION PICTURES

For special problems, Professor Edgerton and his associates have developed a method of taking ultra-slow-motion pictures. The camera has no shutter. The film is driven continuously by a motor, the speed of which can be set as desired. A commutator on the sprocket which drives the film causes a large stroboscope to flash at intervals which coincide with the frame divisions in the conventional 35-mm moving-picture film. With this apparatus, ultra-slow-motion pictures can be made at speeds up to 6000 frames per sec.

This type of equipment is best adapted for studies where a single observation per machine cycle is not sufficient, or where multiple exposures on a single negative are confusing. It enables a continuous series of pictures to be taken of a single cycle of machine operation. It accomplishes the same results as the various moving-picture cameras that have been described, but permits greater magnification of time than is possible with other cameras that are available.

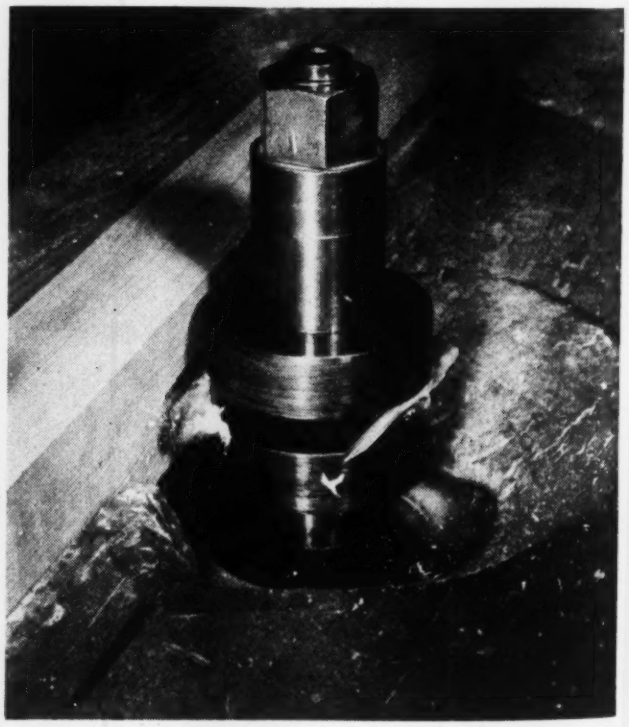

FIG. 7 VIEW SHOWING OPEN-HEAD-MOTOR REED CUTTER TRAVELING AT SPEED OF 7100 RPM

(The chips of wood flying off the cutter itself can be seen in the foreground. The cutters in this view are traveling at a speed of approximately 90 mph.)

PROGRESS REPORT *of an* AMATEUR ECONOMIST

By RALPH E. FLANDERS

PRESIDENT, JONES & LAMSON MACHINE CO., SPRINGFIELD, VT.

MY GRATITUDE is due to The American Society of Mechanical Engineers for an opportunity to pursue a course of adult education under the most favorable circumstances that can be imagined. This began when William L. Batt, then chairman of the Meetings and Program Committee, gave me an opportunity to display my confusion of mind in contrast with the thoughtful analysis of a famous economist, Dr. Wesley C. Mitchell, on the platform of the Engineering Societies Building Auditorium.[1] It was continued through the kindness of the Society in printing numerous addresses and papers in MECHANICAL ENGINEERING.

In particular it permitted the assemblage of a group of fellow students under the banner of the American Engineering Council whose three reports[2] (one of them never released for publication) aroused much interest and led to a wide acquaintance and a mass of correspondence with economists, professional and amateur.

Tonight I stand before you to give an account of the training which the Society has made possible. I do this with some trepidation, for I have come to certain conclusions. In the field of the social sciences this is a dangerous thing to do. So long as one is still searching and researching, he is a serious student of a reputable science, and is entitled to much praise. But when he has reached conclusions, he becomes a crank. I have reached conclusions.

This I say with less shame because I stand in an assemblage of engineers. The engineer is never satisfied to pursue truth as an abstract good. He does not rest until he has organized the abstract truth into the mechanism of life and living. In an endeavor to affect favorably the life and the living of our generation, I present tonight the best thought I have to offer on two subjects. The first is the control of unemployment—our greatest domestic problem. The second is a comprehensive proposal for organizing our economic life, which I call a "Design for Living in America."

II

Unemployment, our "No. 1 Problem," is not a single, but a multiple, problem. Among its elements are the following:

1 *Frictional unemployment*, which is the total of the workers normally and temporarily out of employment at any given time. It has been estimated as being anywhere from two million to four million men in good times.

2 *Agricultural unemployment*. This is composed of dust-bowl refugees, uprooted share croppers, unemployed farm hands, and the like.

3 *Stranded populations*, such as those of overdeveloped or worked-out coal-mining regions, or of towns from which large industries have disappeared.

4 *Construction work*, particularly the building trades.

5 *Depression unemployment* in industry.

Considering first the nonindustrial groups, the appropriate solutions begin to appear. For frictional unemployment we have unemployment compensation, which should be expanded to cover every possible occupation and every region which can be adequately organized. Where frictional unemployment exceeds the period of unemployment compensation, the first recourse is relief, which it is now pretty well agreed on should be under state administration and support, with federal subsidy coming in when the burden exceeds the limits of local responsibility.

Aside from regular seasonal unemployment in agriculture, such problems as those of the share croppers, the dust-bowl refugees, and certain of the other stranded populations as well, will best be solved by a determined and large-scale effort to reestablish and expand the farm home in agriculture. Throughout the South and in the new regions in the West coming under irrigation, there are great possibilities for establishing the self-supporting family with only such a volume of cash crops as will provide for those necessary elements of subsistence which cannot be raised on the farm. Such a procedure would diminish the load on relief and not greatly increase the production of staple crops, which increase will otherwise be the inevitable result of the government's continued expansion in irrigation policy.

It is not too much to say that the main jobs of the Department of Agriculture should be two, of which the first is expanding by education, organization, and moderate financial support, the whole area of farm-home agriculture. The farming areas have always been the great reservoir of industrial workers. The farm-home development will make these reservoirs into regions of comfortable living, not of substandard misery.

The other job is the vigorous prosecution of research for new industrial farm crops to relieve the overproduction of staples.

These undertakings will tend to solve problems of agricultural unemployment instead of intensifying them, as does the present policy, which looks toward subsidizing an overlarge population engaged in staple agriculture at the expense of the working populations of industrial areas.

In some cases stranded industrial populations can be balanced against adjacent agricultural areas, as was the original intention of the T.V.A. before it went "haywire" on its anti-utility campaign. A careful analysis of some regions would indicate an organization of local industries and agriculture which would be in fair balance, and give to both the industrial and agricultural groups a higher standard of living from local resources than they can enjoy without such an integrated activity.

Lastly, there remains the construction industry, in which

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[1] The addresses delivered by Mr. Flanders and Dr. Mitchell on this occasion are to be found in MECHANICAL ENGINEERING, vol. 53, 1931, pp. 99–110.

[2] "The Balancing of Economic Forces" (First report), MECHANICAL ENGINEERING, vol. 54, 1932, pp. 415–425. "The Balancing of Economic Forces" (Second report), MECHANICAL ENGINEERING, vol. 55, 1933, pp. 211–224 and 295–304.

An address delivered at the Spring Meeting, Worcester, Mass., May 1-3, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

there is the greatest opportunity for labor and industrial statesmanship that is open to us in this country. Were it possible for the manufacturers and distributors of building materials, the contractors, and the labor leaders to get together on a joint program for the lowering of costs, one very large and intractable block of unemployment could be removed within a very short time. This situation is a challenge to the intelligence of the factors involved. Unless they are willing and able to come together at their own initiative, they cannot properly complain if the government lays heavy hands on their freedom of action, under the antitrust laws.

III

We have omitted without apology two of the usually emphasized categories—technological unemployment and the problem of youth.

Technological unemployment is not taken seriously as a long-range problem by any recognized authority on the question. It is a serious short-range problem and a serious and sometimes insoluble problem for thousands of individuals. It comes in the classification of frictional unemployment, or even in that of stranded population. The indicated remedy for the many individual cases which extend beyond the normal period of adjustment is that of retraining for new occupations. What has been said of stranded population is applicable whatever its cause—whether technological, exhaustion of resources, or any other.

The problem of youth should not be considered as one completely separate from the other categories. The difficulty which the boy or girl finds in getting a job would disappear were general unemployment to disappear. There does remain the fact that the boy or girl, man or woman, who has nothing to offer beyond physical strength or energy, will find fewer and fewer jobs open as the years go by. Mere physical labor is fast going out of date. Better training and education are needed, and for many it must be vocational rather than exclusively academic.

IV

We have examined a variety of kinds of unemployment and suggested a variety of remedies. It might seem from our study thus far that these various plans would bring the evil under control. This could not happen immediately, of course, for most of the policies proposed are long-range ones from which no immediate result can be expected. But even if we were prepared to put these policies into effect, they would not, I am sure, furnish the complete answer to unemployment, even though they would play a large part in diminishing the size of the problem. More fundamental remedies are needed, particularly for the sudden, large-scale appearance of unemployment arising from a major depression.

On this large scale, our first concern has to do with the steadying of our economic mechanism so that unemployment shall appear less frequently, to a less degree, and for shorter periods. This side of the problem has had a great deal of study applied to it, and I shall not endeavor tonight to analyze such consensus of conclusions as may exist as to the banking, industrial, and political controls necessary to minimize the extremes of industrial activity and industrial employment. I am only going to say that I find nowhere among responsible and recognized authorities on this subject any conclusions which lead me to believe that a completely effective set of solutions is available. We can see some of the follies of the past. We can avoid these past follies, but the human mind is infinitely fertile in the conception of new ones. We have, in fact, found a new way to bring on and to intensify each new depression. We can say quite definitely that whereas we have learned much about the control of depressions, we have not learned enough to assure us that they are really under control.

V

The details of what I conceive to be effective policy for the control of the remaining cyclical unemployment lack novelty and excitement, for on first appearance they resemble just what we have been doing for the last six years.

The direct solution for unemployment is employment. The proposal is that, after the preceding measures have been put into effect, the government furnish employment to approximate the amount of existing unemployment beyond a figure which may be established as a liberal estimate of frictional unemployment. This is to be done not on some debatable theory of consumer purchasing power, or pump priming. The theory is the very simple one of furnishing employment to the unemployed. If we are to survive as a capitalistic, democratic nation, we *must* provide employment. If, by the means already suggested, we can keep the size of the problem within bounds, we *can* do it.

Let us list seven additional requirements for the control of the problem of unemployment and note that we have in the last six years met no single one of them.

1 It is necessary to develop our employment service to the point where it can give current information on the amount, kind, and location of existing unemployment. This we are not prepared to do.

2 We must have innumerable useful projects prepared in advance so that if unemployment appears, projects will be ready for the immediate employment of the unemployed. In spite of the fact that this has been discussed since the beginning of Mr. Hoover's administration, we have not yet put it into effect.

3 The work must be as nearly normal as possible and not used as a means of affecting wages, either up or down, or either for or against unionization. Our policies on government work have been the reverse of this.

4 The projects must be noncompetitive with private business if private business is to be encouraged to develop initiative for expanding to take up unemployment. The reverse of this has been our policy.

5 Projects must be released by an administrative board under instructions from Congress to match them with the amount, kind, and location of developing unemployment. Instead of this, projects have been undertaken for political reasons and in accordance with local pressure.

6 Such expansion of government employment in times of unemployment must be accepted by business as being normal and remedial. The reverse has been true. Business has been frightened instead.

7 All government policies with relation to business must be based on the endeavor to expand private employment, production, and consumption. Instead, the government's relations toward business have been based on abstract theories of numerous and varied sorts in which the primary element of maintaining employment has been disregarded with a carelessness little short of criminal.

To put it in a sentence, we have not employed up to date *a single one* of the essential elements of an effective policy for solving the problem of unemployment.

Now, let us come finally to the fiscal problem. It is my firm belief that we have spent much more than enough money to revive normal business and employment. The fault has not been that we spend too little. We have spent too much, and that excess has been without effect. Had we attacked the separate elements of the problem rationally, and had we followed the essential requirements in providing governmental employment, a much smaller sum and a much smaller increase

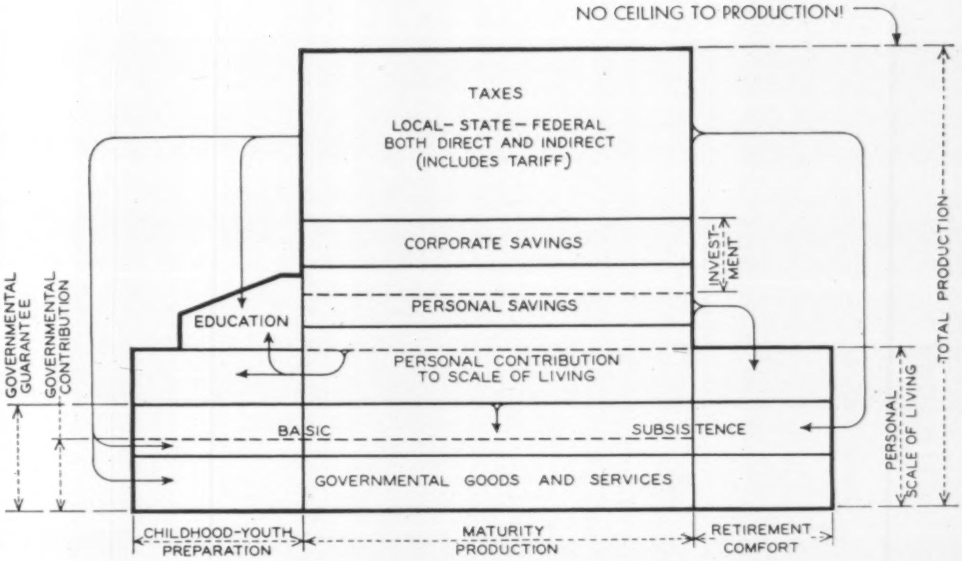

FIG. 1 DESIGN FOR LIVING IN AMERICA

of our national debt would have sufficed to put us into a state of employment and productive activity comparable to 1929 but on a much sounder basis. As a result of our failure, we have had to wait for a new world war to give us any assurance that the unemployment problem might soon be under control.

VI

With unemployment under control by the preceding means, or by any means which does not depend on an authoritarian government, we shall find presented to us the greatest opportunity for social advance which has been offered to any nation. We shall be ready to prepare a rational "Design for Living in America," and to guide the evolution of our country toward the completion of that design.

Let us construct such a design on the blackboard. Let us see if it meets the possibilities and needs of our people. If so, let us see what we can do toward establishing it as a reality.

The plan here presented is based definitely on capitalism. This selection of one system, and the arousing of a determination to work under it and under no other, is no light matter. It is a decision of the greatest importance. Much of the confusion, waste, and tragedy of the last seven years has been due to rendering lip service to capitalism while installing continuously one after another of the elements of state socialism. It being a characteristic of that system that failure of initial attempts requires still further applications of the same as the only obvious cure, we have been led in this direction with ever-increasing speed. No matter how earnest and honest the protestations of those who are leading us, the pathway they have chosen leads downhill into totalitarianism. It is only in recent months that many of us have realized that we are in the rapids and that the falls are ahead. We want to stop, and to proceed by a safer route. We need to tie our Ship of State to the bank, while we climb some elevated lookout where we can see the whole territory ahead.

Such a look ahead can result in a chart, with a safe route plotted through it; and such a chart is presented in Fig. 1, over the title "Design for Living in America."

Horizontally, the diagram represents the span of life of an average man and wife. It is divided into three parts. The left-hand section is that of childhood and youth, and the activity of this period is that of education and preparation for the lifework of maturity, and for the higher satisfactions of maturity and age. The second period is that of maturity, and its activity is that of producing and distributing goods and services. This period supports itself and the other two periods. The final period is that of retirement, with no required social activity, and with the privilege of comfort and rest.

The vertical lines separating these periods are not drawn at any arbitrary points. For instance, the period of childhood, youth, and preparation will end for some at an earlier period than for others; retirement will come early for some, later for others.

Vertically, distances represent goods and services produced and consumed. This measurement must be conceived in terms of volume, even though there be no common measure of volume for wheat and dental repairs, for instance. We could put the measurement in terms of dollars-worth, were there no danger of our thinking in money terms, instead of physical terms. Perhaps we might lay out the diagram in dollar values, and then erase the dollar sign from our minds, thinking only of the goods and services which dollars will buy, and for which they may be sold.

VII

Let us start at the bottom of the diagram and work up.

Government provides certain social "goods and services" as distinguished from private ones, which are available to the citizen throughout his or her life. Among them are included such things as highways, postal service, sewage disposal, water supply, parks, agricultural experiment and information, protection by police and armed forces, food inspection, and many things besides. Two hundred years ago most of these services then existing were private, and many of them were available only to the well-to-do. Still more of them did not exist at all. They have now greatly increased in volume and are more completely available to the whole population. We must expect them in the future to increase still more and to become ever more widely available. Not only do we expect this to be so, we wish it to be so.

The next area, "basic subsistence," represents a conception new to us which has been taking form in the last decade. It is here expanded to a point beyond any proposals yet implemented by law or custom. The proposal is that government guarantee basic subsistence to every individual in the United States throughout his whole life. By basic subsistence is meant simple food, clothing, and shelter, without luxury or waste, but also without niggardliness, opprobrium, or undue red tape. "No one shall starve" is the old concept—negative and reluctant. Guaranteed basic subsistence is the new concept—positive and ready.

For childhood and maturity the individual head of a family bears the primary responsibility. The mature man does his best to support himself and his dependents in accordance with the minimum standards of health and decency implied in basic subsistence. In case of failure, the government steps in. If the failure is due to inability to find work, the government provides a job, as already suggested. If failure is due to laziness or obstinacy, the delinquent is put in a work camp and is compelled to do his share of productive effort, while his family is supported by the government. If illness, death, or other misfortune is the cause of failure, again the government steps in.

All of this relates to the family with children, and is based on the interest of the whole nation in the welfare of its future citizens. For the adult without dependents the case is different. If he prefers to live at a low level, he may. He does not have to live so, for the government will provide work for him. Maybe he prefers a wandering life, at odd jobs, or playing the fiddle. This is a free country so long as freedom does not injure helpless women or children. But let him not try to extort handouts with hard-luck stories. There will be no hard luck. In the America which we are planning there will be a place for the troubadour, but short shrift for the panhandler.

For the aged, basic subsistence will be freely available on application, and no sense of shame will be felt by those who have earned it in maturity by the production of goods and services, or by serving the needs of dependents.

Basic subsistence will naturally be different in nature as between the Ozark mountains and Manhattan. In the one case it will be based on the farm home; in the other, on work for wages. But whether in one place or the other, it means freedom from privation and means for the maintenance of health.

As will be noted in the diagram, the actual government "contribution" will be much less than the "guarantee," for the reasons already explained.

The majority of the population will live well above the level of basic subsistence, and this increase in the scale will be effected for each by his or her "personal contribution to the scale of living." By the productiveness of work each does there will be an excess of goods and services for the enjoyment of himself and his dependents.

These three factors—governmental goods and services, basic subsistence, and the personal contribution—add together to produce the personal scale of living of the individual.

But we must maintain equality in political power, and attain equality in opportunity; and the consideration of either brings us to study the area marked "education;" for without more, different, and better education than we now possess, political power is dangerous and equality of opportunity is impossible. Much has been thought, said, and written concerning education as the safeguard of democracy. Much more remains to be done. But this is a little away from our subject.

Our primary concern is with equality of opportunity. This is an ideal which we can never reach (due, in part, to an inescapable element of chance) but it is an ideal which we must vigorously pursue, and one which we may approach much more nearly than we do at present.

The purpose, more definitely stated, is to subject every child in the United States to such a kind and amount of the educative process as shall develop his or her innate capacities to their full extent. This requires an expansion of education geographically into all sorts of benighted areas. It requires an expansion in volume to serve more pupils for more years. It requires an expansion in varieties now known and in others as yet unknown, to adapt it to the incredible variety of useful capacities which are to be found in this fortunately heterogeneous nation. This is a social undertaking of unprecedented magnitude, and like other elements of the design will occupy years of exploration and progress.

Before leaving this important subject, some details should be noted. As stated earlier, the differences in the types of abilities of children will lead to wide differences in the period required for their education. With some the process will end at 16 years of age, and with more, at 18. Others will be ready for the productive life at 21. Some will be preparing themselves until 25 or 30, and for the chosen few education and production will go hand in hand until "death do them part."

Provision is made for both public and private support of education. Freedom must be left here, as in other areas. Yet for its own sake the government cannot permit inadequate or lopsided private training to take the place of a full and suitable one, under whatever auspices.

There must also be provision for cultural education for all. This cultural education must be more broadly organized than at present, and be aimed directly toward training the boy or girl for the greatest possible satisfaction in living that the particular boy or girl can attain. It may not include foreign languages. It may include square dancing, botany, pole vaulting, or hand weaving.

Finally, an essential element of our educational program must be the fixation in the mind of the child of the idea that at the end of the process he is on his own. Society has taken great pains and has been to great expense to train him for life. At the end of the training the support is removed and his personal responsibility begins. Until now, the government has supported him. From now on he supports the government.

For in all the greatly expanded governmental services contemplated in this design, there is no element which weakens personal responsibility. For lack of a plan and method, the soft-hearted ways in which we are expanding some of these services at the present time is eating away the moral supports of democracy.

In this connection an evident difference in the scale of living—as between one citizen and another—is socially desirable. If we see to it that income is based primarily on productivity (a point to be discussed further), if education gives a near approach to equality of opportunity, and if productive work is open to all, then elements of injustice in differences of income will be small indeed, and these differences will spur the ambition as in the earlier days of American history, instead of wasting their influence in a futile sense of injury as tends now to be the case. We must have more "success stories," and they must be true stories. The heroes of them must be visible to the eye. And it must be clearly evident that the pathway to such success is open to character and ability, through training which is likewise open to all.

On the negative side, it should be noted that we shall have removed the burden of justifiable fear from the heart of man and woman, child and the aged. A chance to earn basic subsistence for the whole span of life and adequate preparation for those entering upon it are guaranteed by government. Worry is banished. Justifiable hope and ambition succeed it as the mainspring of economic and political activity.

For many citizens there will be available a net volume of goods and services greater than they wish to consume in current living. This excess goes into "personal savings," and may ultimately be employed in various ways. It may be stored in negotiable form to add comforts and luxuries to the basic subsistence guaranteed by government for old age. Or, it may be invested in industry whose needs for new capital will be great, and whose returns will be sufficient to warrant the saving. Other large contributions to investment will be made by "corporate savings," in which the equities of the individual citizen are reinvested without having first passed through his hands.

The need for new investment will be great. In the first place, there are yearly great business losses which have to be made up by fresh capital. Then there are great fields for research, resulting in new inventions, products, and processes which have to be developed, financed, and brought to full production. There is also the need for a complete re-equipment of American industry to make it possible to pay the current high wages to all at existing prices of the product—for high wages and low production can have no other result than high prices and unemployment. We do not now have installed the equipment to support our high wages. Finally, our Design for Living contemplates an enormous expansion of productivity and the producing plants of the nation will have to be expanded correspondingly, particularly if our plans for the future contemplate the elimination of night work for all except continuous process industries. We face a great need for savings, because we will have a great field for investment.

At long last we come to the piper's bill, for the nation whose design for living is as ambitious as this must be prepared to pay the piper.

The large area at the top of the diagram is "taxes." They go for "governmental goods and services," "basic subsistence," and "education"—all of them expenditures on an enlarged scale beyond our present seemingly extravagant expenditure. If we are to have these benefits from government, the tax bill will be a large one. And if we are to be able to foot the tax bill, the total productivity of the average individual must be higher than now.

VIII

At this point we will do well to shift our diagram from an economic life history of the individual to one which is a summation of the receipts and expenditures, production and consumption of all the individuals composing the nation for any given year. Viewed thus, the scale of living becomes the total scale of living of the nation; the total productivity is the total annual income of the nation; the sum of individual taxes becomes the total annual taxes of the nation, and so on.

It will then more clearly be seen that the prime requirement of our design is the ability to produce a surplus large enough to be taxed to support governmental activity on a large scale, while still maintaining a greatly improved standard of living. There is no way to support this save from the productive activities of our citizens during their productive years. If that productivity is not great enough, these things simply cannot be done! This we have been unwilling to admit up to this time, and in the endeavor to consume more than we produce we have run up fantastic governmental debt on the one hand and, on the other, have rendered the needed governmental support only scantily and with fortuitous or arbitrary distribution of benefits.

It is an incredible folly to seek the expansion of governmental benefits under these conditions. It must surely be crystal clear that our nation is faced with a major problem in domestic policy. That problem is: How can we increase production? The well being of every citizen and the solvency of his government depend on finding the answer. The solution of unemployment depends upon it. The two problems are one.

Except for a right-about-face in governmental attitude and purpose, there is no one answer. There are many things to be done, some of which will be indicated; but the main point is that every governmental policy should be tested first of all by asking the question: "Will it increase the production of goods and services in the nation?" If the answer is "no," then the reasons for the policy will have to be extraordinary indeed to warrant adoption. If the answer is "yes," objections will have to be serious indeed to warrant rejection.

By this time it will have become clear that the design is not a plan which can be inaugurated by simple legislation and set in motion by some new alphabetical administrative bureau. Putting it into effect is a continuing effort, which must extend over a period of years. On the whole it does not depend so much on specific new legislation, though this is essential; its greatest usefulness is as a standard of reference with which every governmental, labor, business, and financial policy will be compared. Does or does not a given policy fit into the design? If it does, and if it appears to be workable, it is a good policy. If it does not, away with it!

Of course, it will be possible to improve the design, but let us be sure that we have an improvement before we apply it. Let us beware of changing just to admit some law or policy whose superficial brilliance has bedazzled us.

IX

To return to our description, a few elements of positive policy may be noted. They are mostly of the type which restores business to the more healthy of its former freedoms. We have been living in an era in which the assumption that capitalism is dying has led to the application of such drastic remedies as bleeding, and the application of the remedies bids fair to make good the faulty diagnosis.

It is indeed fundamental to the design that the expansion of governmental activity be recognized, while the contraction of governmental control is insisted upon. The distinction is not vague. It can be clearly made.

Taxes should stimulate business activity rather than repress it. They should be laid on achieved personal income more heavily than on corporate profits from business activity. In particular, we should avoid such imbecilities as the former undistributed profits tax, which made no distinction between liquid profits and profits reinvested. The latter were profits which had gone back into the market for goods and services instead of lying in idle bank deposits. Heaven knows we needed money that went to market and made the wheels go 'round, but such money was penalized as heavily as if it were idle.

The power of labor and capital must be brought back into balance. When the power is in the hands of capital, we have inadequate distribution of returns to labor. When the power is in the hands of labor, we have diminished production—for that is the history of much "successful" labor organization. Into this area of social action and reaction we must bring the old and tried American principle of checks and balances. The Wagner Act must be amended to give no preponderance of protection against either party, and to guard the vote of the independent workman as carefully as we try to guard the vote of the independent citizen at the polls.

As to controls of business, we must see to it that cooperative enterprise has a free field, with no unfair advantages allowed to private business, large or small. In a free field with no favor the cooperative movement can demonstrate whether or no it possesses survival value.

The eternal war against price maintenance by agreement must be pursued relentlessly. The business organization which can produce more goods profitably for a lower price must be encouraged.

Unfair competition made possible by size must be punished.

This includes the selling of goods at a temporary loss in the area of a small competitor so as to put him out of business. All of these things tend to reduce the volume of production.

Controls of finance and the restoration of certain of its freedoms are both needed. As to controls, central bank and governmental policies must distinguish between business enterprise and pure speculation. The one risks capital in the production and distribution of goods and services in the hope of an ultimate profit. The other attempts to realize now on possible or impossible profits in the far future. There is a twilight zone between the two, but the difference is easily discernible at the extremes. In times when speculation outruns enterprise, there should be an increasing pressure of counteracting central bank policy—not a single sudden and tremendous explosion of all available ammunition at once, as in the case of that grand salvo which blew to smithereens the infant boom of 1937.

But even more are new freedoms needed for finance. S.E.C. policies must be revised to encourage and expedite investment. This need is critical, and it is cause for astonishment that we have by legislative enactment and administrative policy set up a body which has, and uses, the power to choke investment, and thus slows down employment and production. It is not merely impossible to take the danger of loss out of investment. It is actually undesirable to do so. Above everything we need a revival of business enterprise, and that means business risk and the possibility of loss. Protect us from danger, and we stagnate. The useful role of the S.E.C. lies in the elimination of falsehood and deception from the prospectus. Beyond this it should not go.

We have set up these ideals: Equality of opportunity; free negotiation in the markets for labor, goods, and services; and the curbing of profits from speculation in favor of profits from production and distribution. In addition, our inheritance laws, for good or ill, prevent the effective transmission of great wealth from generation to generation. We are now in a situation in which reward is more nearly proportional to service than was the case a generation ago. The silver spoon is rare in the mouth of the third generation, and will become rarer still. If we can carry out our design, the coming years will bring a still closer correspondence between service and reward.

X

More—much more—might be said as to the details of governmental, labor, business, and financial policy which would increase production; and agricultural policy is a whole subject in itself. This address is already long enough. Yet, space must be found for referring once more to an element of policy which business must understand and accept, and which government must organize on rational lines. That policy is the effective use of governmental employment in times of unemployment resulting from business derangements.

It was said earlier that government should guarantee basic subsistence, and for the adult and his dependents this should be done by furnishing employment when private employment fails. It was also said in effect that the area of social goods and services furnished by government had increased, was increasing, and ought to increase. It may also now be said that this area is capable of rapid expansion and contraction to match the expansion and contraction of unemployment. By this means employment and consumer demand may be steadied, production revived, and the extremes of business fluctuation and social disintegration avoided.

All of this demands a technique which has had some study, but, being available in book form, will not be summarized here.[3] It is necessary for government to acquire this missing technique. But it is equally necessary for business to accept this recurring large-scale expansion of governmental employment as being remedial and helpful to a revival of private production and distribution. If the process is well managed, by an administration whose primary purpose is the revival of private production and distribution, why should business be afraid of the maintenance of its consumer market? It must not merely reluctantly accept, it must vigorously push the adoption of the policy, for it is the regulating governor of the Design for Living in America.

Business has more than this to do. It has the opportunity to accept and to sell the Design to the American people and through them to our government.

XI

Both business and government have lost face in the last decade. With business and finance in full control of our economy from 1920 on, we went on the rocks in 1929, and by 1932 the ship had been pretty well pounded to pieces. In the years since then the new administration has floated the craft into protected water and undertaken repairs. These repairs have been designed to reconstruct the ship completely, in accordance with plans which change yearly, monthly, almost daily; and the result is a dubious craft indeed. It has never made a paying voyage. It is hard to believe that it ever will—unless with a cargo of war material.

Hitherto discredited business has accrued further discredit by an exclusively critical policy. It has pointed out the absurdity of this and that expedient. It has been right; but critical rightness solves no problems. The time has come for business to take the initiative—to have its design for the reconstructed Ship of State—its Design for Living in America. The time has come for business to sell its design from Canada to Mexico, from Cape Hatteras to the Golden Gate—to convince the nation that it has learned something since its decisive failure of a decade ago.

Is it prepared to do so? The recent "Declaration of Principles" of the National Association of Manufacturers gives evidence of the courage, social responsibility, and intelligence which exist in American business. Perhaps the opportunity will be seized.

The danger to our capitalistic system from uncontrolled unemployment is not a temporary political phenomenon. It is the surface evidence of one of the great ocean currents of history which we cannot reverse or stop but which we can discover, survey, and adapt ourselves to. If we treat it in this way, it will bear us to a desired haven.

The destructive force of unemployment is fear. Fear in lands abroad has exploded in revolution. If allowed to recur and increase, it will do so here. There is no fear that clutches the heart and stirs the mob spirit like the fear of destitution for one's children and for one's own old age. That fear we can and will remove. Fear has never been the dominant motive in American life. To justify it as a necessary controlling element is to open a new and dark chapter in our history. For the citizen able and willing to work, a secure opportunity to do so must replace destructive fear. Those with the ability to expand production and employment must regain ambition and be inspired with justifiable hope. We must bring this about. With business and government abandoning their foolish policies and attitudes and working in harmony, we can and will bring this about.

Then will America surely be what she cannot now long remain—a safe and a happy nation.

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[3] "Toward Full Employment," by Dennison, Filene, Flanders, and Leeds, Whittlesey House, New York, N. Y., 1938.

Turbine-Blade FATIGUE TESTING

By R. P. KROON

MANAGER, EXPERIMENTAL DIVISION, WESTINGHOUSE ELECTRIC & MANUFACTURING CO., SOUTH PHILADELPHIA, PA.

ANY strength problem is of a dual nature. To decide whether a design is safe or not, one should know:

1 The forces acting on the structure;

2 The strength of the structure under the loading caused by these forces.

In this paper we shall confine ourselves primarily to the second part of the problem. Apart from some introductory remarks, no attention will be given to the exact nature and origin of the forces to which blades are subjected.

The character of the forces acting on turbine blades is much more complicated than is at first apparent. There are the obvious "steady" stresses due to centrifugal force, driving torque, and pressure drop, and, occasionally, there are stresses due to differences in temperature of the parts. However, by far the most important are the vibratory stresses to which blades are subjected.

The significance of vibratory loading on the blades seems to have been recognized at an early stage. In 1912, Francis Hodgkinson, then turbine engineer of the Westinghouse Company, wrote:

"It is a fair statement to make that scarcely any turbine of anybody's make ever gave trouble due to blades breaking or coming out because of centrifugal force. It is not centrifugal force which breaks blades, but the vibration of the blades themselves. Of course, there have been cases where, due to misalignment of parts, the moving blades have collided with the stationary blades or parts. There have also been cases where the cylinder was distorted causing blades to rub on the casing. Such things, of course, will cause injury no matter what the type of turbine, and irrespective of how massive the blades may be.

"As stated in the foregoing, the real trouble which has been experienced by all manufacturers of turbines whether of the impulse or the reaction type, and from which we ourselves have not been immune, has been due to the blades vibrating in the steam current, that is, 'buzzing.' "

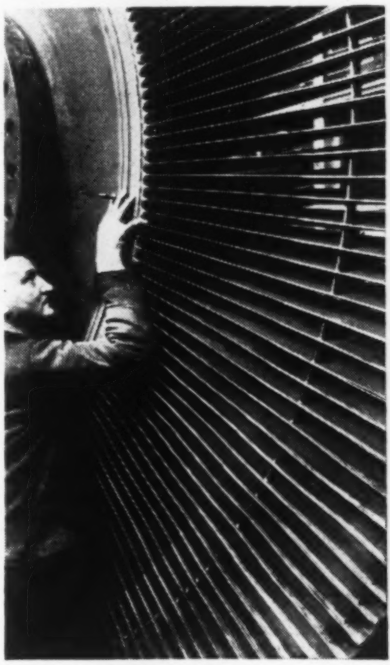

FIG. 1 TURBINE DISK CARRYING SEGMENTS OF LOW-PRESSURE BLADES

FATIGUE FRACTURES DUE TO VIBRATORY LOADING

The wisdom of this statement, made 28 years ago, has been amply proved in operating experience. When blade failures occur in actual service, they nearly always exhibit typical progressive fatigue fractures characteristic of vibratory loading. These fractures show no reduction in area and usually are easily distinguished from ruptures due to a steady loading. It is essential that in any mechanical-strength tests the type of loading be of the same nature as that to which the blades are subjected in service. This points to the necessity of fatigue tests with oscillating loads to study blade constructions.

To obtain high strength, it is customary to group blades together in segments by means of shrouds or lashing wires. Fig. 1 shows a typical arrangement. The blades in this case are tapered and twisted low-pressure blades. Such segments can vibrate in several natural modes. Fig. 2 is a composite picture showing the principal modes of vibration. The photographs reproduced in this figure were made up by shining a strong light on the tips of a segment of six low-pressure blades.

In Fig. 2, view *A* was taken with the blades stationary; *B* shows the blade tips with the segment vibrating at the lowest natural frequency. In this first mode, blades of this type deflect in a direction approximately perpendicular to the minimum axis of the blade cross section near the base. All the blades move in phase. The lashing wire or shroud is deformed into an S shape between adjacent blades.

A second mode *C* (Fig. 2) exists, in which the deflection takes place mainly about the maximum axis of the blade sections near the root. The direction of motion of the blade tips is approximately perpendicular to that of the first mode. Again all blades move in phase with each other.

A third natural mode of vibration *D* (Fig. 2) consists of a torsional motion of the group as a unit; there is a node in the middle of the segment. Blades on opposite sides of this mid-point move in opposite directions. The end blades of the segment have the greatest motion.

These modes can be analyzed theoretically. Particularly the natural frequencies of the segment can be predicted. These calculations are the more accurate the longer the blades since uncertainties, such as the degree of clamping at the root, become less and less important.

Such analysis also yields a picture of the stress distribution in the segment. For example, when one plots the nominal maximum bending stress along the blade axis for a segment vibrating in the first mode, it is discovered that a "Christmas-tree" diagram, Fig. 3, results. (The term "nominal stress" is used here to indicate that local stresses, such as set up in the immediate vicinity of the lashing wires, have not been included.)

With the segment vibrating in this mode, the highest bending stresses in the blades are at the lashing wires and at the base of the blade. Moreover, these

Contributed by the Power Division and presented at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of The American Society of Mechanical Engineers.

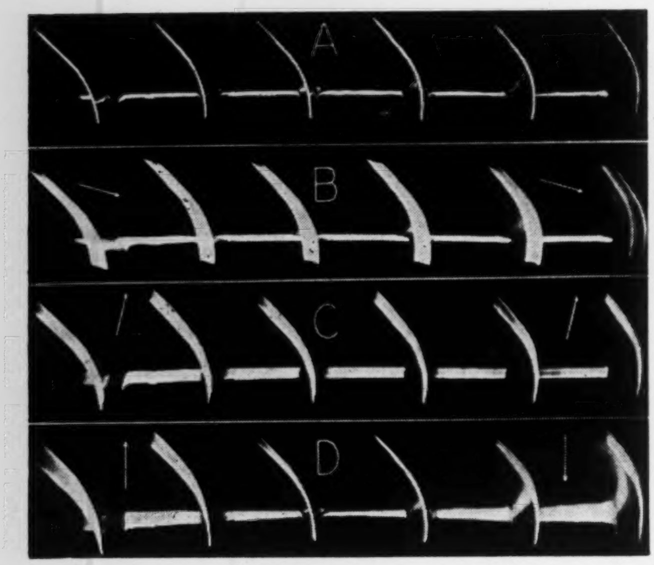

FIG. 2 NATURAL MODES OF VIBRATION OF A BLADE SEGMENT

are locations where local stress concentration exists. The wires are stressed in such a way that the stress is a maximum where they join the blade. This indicates at once the most likely locations in blade and wires for failures to occur.

In former times the location and size of lashing wires were fixed by more or less arbitrary rules. As a result it often occurred that the material was not utilized properly. For example, in a segment with two lashing wires, the stresses in the lower wire might be several times as high as the stresses in the upper wire. Thus the lower wire would fail long before the strength of the other wire, or the blade itself would be endangered.

In an ideal arrangement all wires should be loaded with the same factor of safety, that is, it should require the same amount of overload on the blade to produce failure in each wire. Also, the blade should be stressed about the same amount at each wire joint.

It appears to be a good rule to make the construction such that failure in the wires will occur before the blade itself fails. Any overload will then reveal itself by cracks in the wires rather than by the loss of blades.

SELECTING LASHING WIRE FOR MAXIMUM BLADE STRENGTH

Since the exact amount of stress concentration around the wire sections and at the root cannot be evaluated by calculation, the best method to arrive at the strongest possible combination is to combine fatigue test and analysis. Such work is now being carried out and is resulting in new standard arrangements with superior strength.

Typical of the results of this work is a plot shown in Fig. 4. The blades under consideration are 1 in. wide and 7 in. high. Assuming that one wants to use a single lashing wire to interconnect the blades, the problem then becomes—how to choose the size and location of the wire to achieve maximum strength for this blading.

Fatigue tests were made with various-size lashing wires placed in different positions. In Fig. 4 the diameter of the wire used for a certain test is plotted along the abscissa. The vibratory load which the segment can stand, when equipped with this wire at a certain distance from the base of the blade, is plotted along the ordinate. Thus, for each position of the lashing wire, there exists a curve showing how the mechanical strength of the structure depends upon the wire diameter chosen.

According to the traditional rules previously used, these blades would have a No. 2 size (0.257 in. diam) lashing wire, located 5.6 in. from the base. The diagram shows that this arrangement withstands a load of 65.7 lb. The wire is too small and it fails long before the blade itself carries much stress. By bringing the lashing wire closer to the base of the blade and by increasing its size, the strength of the arrangement can be materially increased. The diagram shows that, with the wire located 4.5 in. from the base, a No. 1 wire (0.289 in. diam) would stand a load of 91 lb. With a No. 0 wire (0.325 in. diam) the segment would stand 101.3 lb and, with a No. 000 wire (0.410 in. diam), the segment would carry 106.8 lb. These loads are between 37 per cent and 62 per cent higher than that of the original arrangement.

At this location and with a No. 1 wire, all failures occurred in the wire. With a No. 0 wire at the same location, the majority of the test specimens failed in the wire, but some cracked through the blade. With a No. 000 wire all failures took place in the blades. It becomes a matter of policy whether one prefers the arrangement with the highest mechanical strength which would fail in the blade, or the somewhat weaker arrangement in which fractures would occur in the wire.

The foregoing problem is of a type which often occurs in blade fatigue testing. Frequently, it is required to test a number of slightly different arrangements and to pick out the best

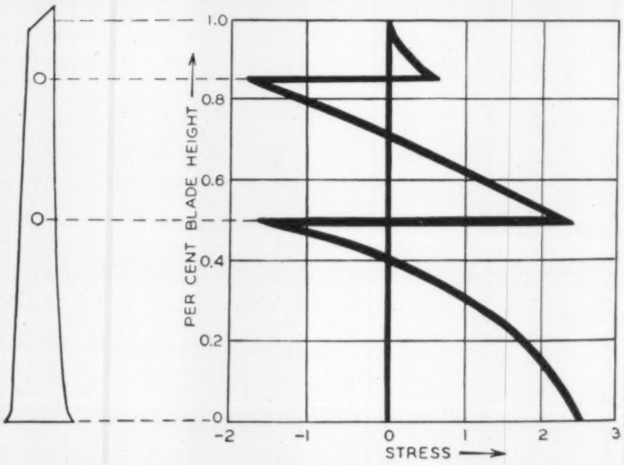

FIG. 3 TYPICAL STRESS DIAGRAM FOR BLADE WITH TWO LASHING WIRES

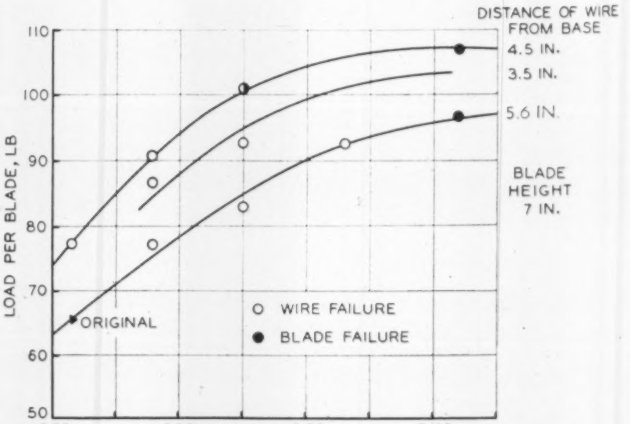

FIG. 4 INFLUENCE OF LOCATION AND SIZE OF LASHING WIRE ON MECHANICAL STRENGTH OF BLADE GROUP

combination. The question then is: How should the tests be made and how should the results be rated?

METHOD OF MAKING FATIGUE TESTS

First of all, to duplicate service conditions, it is preferable to vibrate the specimens at their natural frequency. As with all structures having small internal or external friction, it takes only relatively small exciting forces to build up large motions (and large inertia forces) at resonance. Hence, the exact nature and point of application of the exciting forces is immaterial for the stress distribution in the specimens. However, any extraneous weight attached to the vibrating system, such as may come from the driving mechanism, changes the stress distribution in the system and is undesirable unless its effect can be evaluated beforehand.

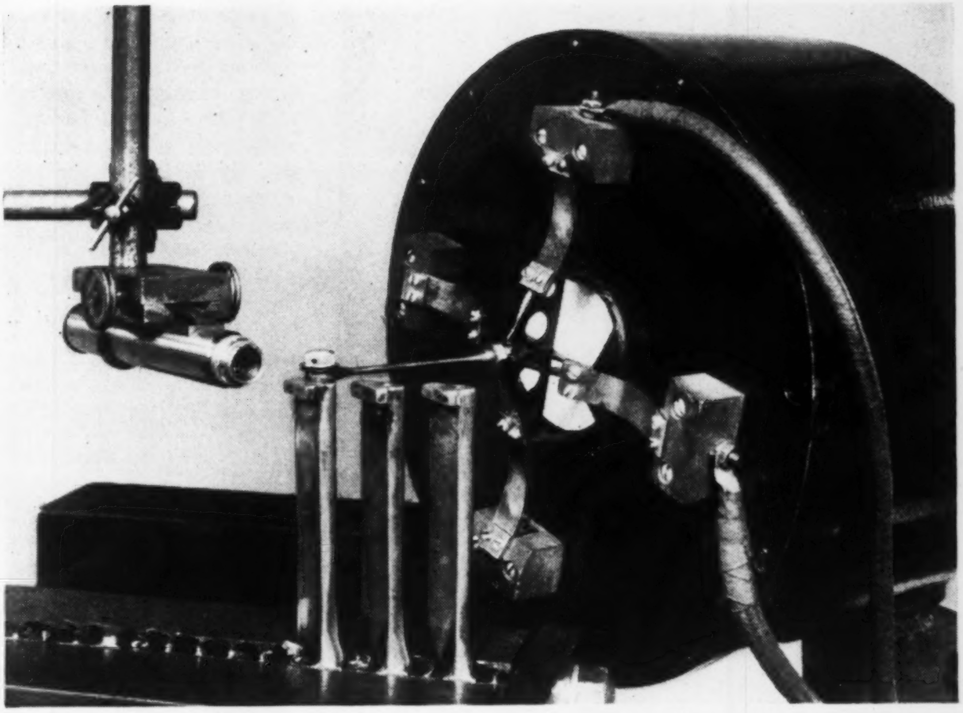

FIG. 6 BAKER-TYPE ELECTROMAGNETIC VIBRATOR

Let us assume here that there are no extraneous weights and that on each arrangement enough tests have been made to arrive at an endurance limit, that is, a loading which this arrangement supposedly can stand forever.

Each structure is thus vibrated at its own natural frequency, f cycles per sec, and can stand an amplitude of say y_1 in. at the blade tip. Each arrangement has a slightly different deflection curve, Fig. 5. How should the various arrangements be compared?

Let us assume that the blades will have to operate at resonance. Let this resonance be excited by a vibratory load equally distributed over the blade length between $z = a$ and $z = b$ and oscillating between $+p$ and $-p$ lb per in.

The work done at resonance on a small element of length dz having an amplitude y is

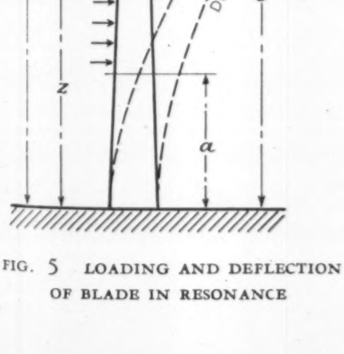

FIG. 5 LOADING AND DEFLECTION OF BLADE IN RESONANCE

$$\pi(p\,dz)y$$

during each cycle. The total energy input over the entire blade length is per cycle

$$\Delta E = \pi p \int_{z=a}^{z=b} y\,dz \qquad \ldots\ldots\ldots[1]$$

The kinetic energy of the specimen is

$$E = \frac{1}{2}\int_{z=0}^{z=l} \mu y^2 \omega^2 dz \qquad \ldots\ldots\ldots[2]$$

in which μ is the specific mass per unit blade length, and in which $\omega = 2\pi f$.

The energy input ΔE and the kinetic (or potential) energy E are related with the logarithmic decrement δ which is a measure of the damping of the system, by the well-known relation

$$\delta = \frac{\Delta E}{2E}$$

Substituting, one gets

$$\delta = \frac{\pi p \displaystyle\int_{z=a}^{z=b} y\,dz}{\omega^2 \displaystyle\int_{z=0}^{z=l} \mu y^2 dz} \qquad \ldots\ldots\ldots\ldots\ldots[3]$$

From this equation the amount of oscillating load that can be carried by the specimen is derived

$$p = \frac{\delta\omega^2 \displaystyle\int_{z=0}^{z=l} \mu y^2 dz}{\pi \displaystyle\int_{z=a}^{z=b} y\,dz} \qquad \ldots\ldots\ldots\ldots\ldots[4]$$

In Equation [4], the weight of shroud or wires can be added to that of the blades at the proper location. If one knew, for each arrangement, the true value for the decrement δ and the deflections y along the blade, corresponding to the endurance limit, Equation [4] would give a measure of the mechanical strength of the setup.

Actually one often finds that slight variations in the setup make it impossible to arrive at accurate values of the damping constant δ. In this case one may want to compare the various arrangements on the basis of $\delta =$ constant.

DEVICES USED TO FATIGUE TURBINE BLADES

In the course of time, a number of devices have been employed to fatigue turbine blades. These include rotating devices with eccentrics deflecting the blades, various crank devices, and mag-

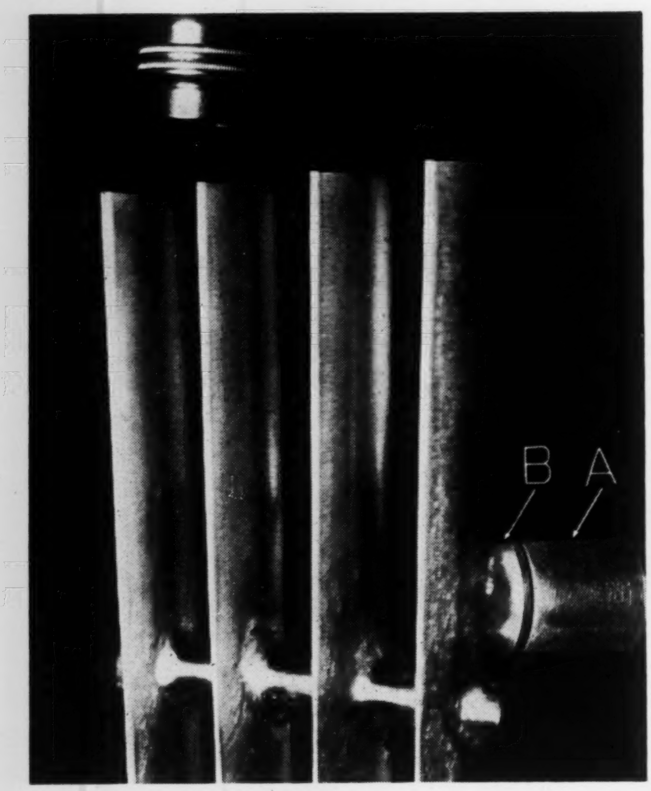

FIG. 7 PNEUMATIC VIBRATOR FATIGUING GROUP OF REACTION BLADES

netic apparatus. At the present time, our apparatus is of four distinct types, each filling a particular need.

To study the various modes of vibration and to fatigue blade assemblies at their natural frequency, a variable-frequency instrument was needed.

An electromagnetic vibrator, Fig. 6, developed by J. G. Baker of the Westinghouse Company has been in use since 1932, and has proved itself to be a versatile instrument not only for blade research, but also for the study of vibrations in gears, turbine disks, blower casings, and the like. Its output is strong enough to vibrate and break an entire segment of blades 38 in. long. The pulsating force is obtained by sending alternating current of the desired frequency through a coil which is movable in the field of a strong direct-current magnet. The coil is connected to the specimens by a slender rod. The variable-frequency alternating current is produced in a small oscillator and stepped up in a 500-w amplifier.

The attachment of a coil to the vibrating specimen presents some disadvantages. Unless the specimens are large, the weight of the coil is annoying since it influences both the natural frequency and the stress distribution in the specimens. When one wishes to explore short stiff specimens, such as impulse blades, it is found that the acceleration of the coil is so high that its own strength is jeopardized. A coil such as shown in Fig. 6 may be required to carry an inertia load of several hundred pounds.

To avoid this difficulty, apparatus was developed which did not require attachments to the vibrating specimens. The pneumatic vibrator,[1] Fig. 7, consists of a nozzle *A* which has the characteristic that it will feed energy into the vibrating system by means of pressure oscillations on the small plate *B* rigidly attached to the vibrating assembly. The resulting vibration is "self-induced," it takes place automatically at a natural frequency of the specimens, and no tuning is involved. The amplitude of vibration is controlled by the pressure before the nozzle.

This type of apparatus is quite powerful and good for extremely high frequencies. It has another advantage; it makes possible the measurement of damping in the vibrating system in the course of a regular fatigue test. By suitable calibration, the energy output of the nozzle can be determined for a given setting and for a given pressure drop across the nozzle with the

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[1] An invention of Dr. H. W. Emmons, formerly of the Westinghouse Company, now assistant professor of mechanical engineering, University of Pennsylvania, Philadelphia, Pa. It appears that similar apparatus has been used before (see "High-Frequency Fatigue," by C. F. Jenkin and G. D. Lehmann, Proceedings of the Royal Society of London, series A, vol. 125, 1929, pp. 83–119).

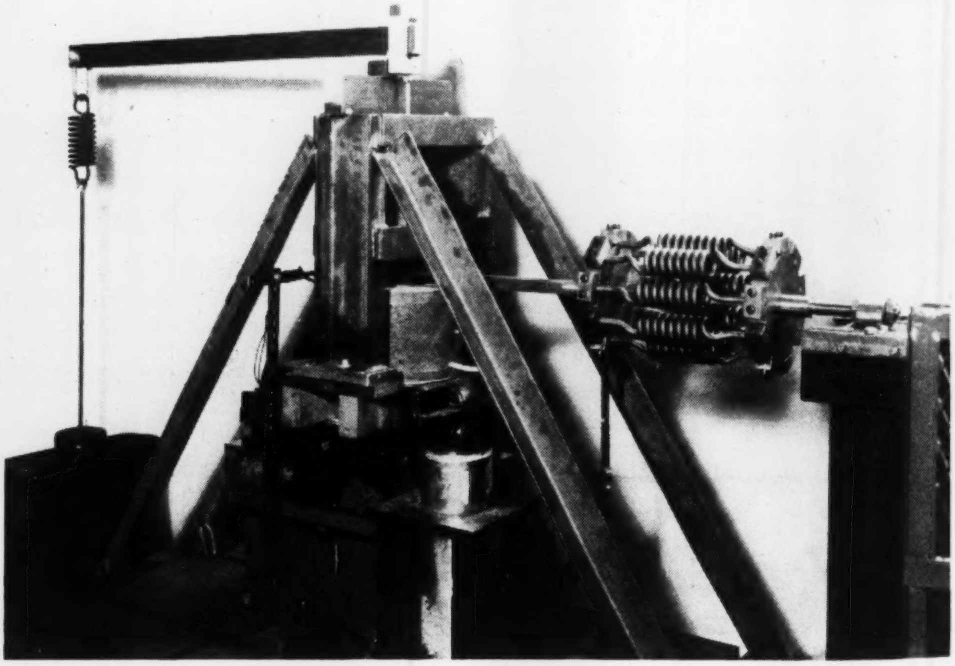

FIG. 8 IMPULSE BLADE BEING TESTED AT HIGH TEMPERATURE ON CRANK MACHINE

(Springs allow push-pull loading; blade is pulled axially by means of weight-and-lever system.)

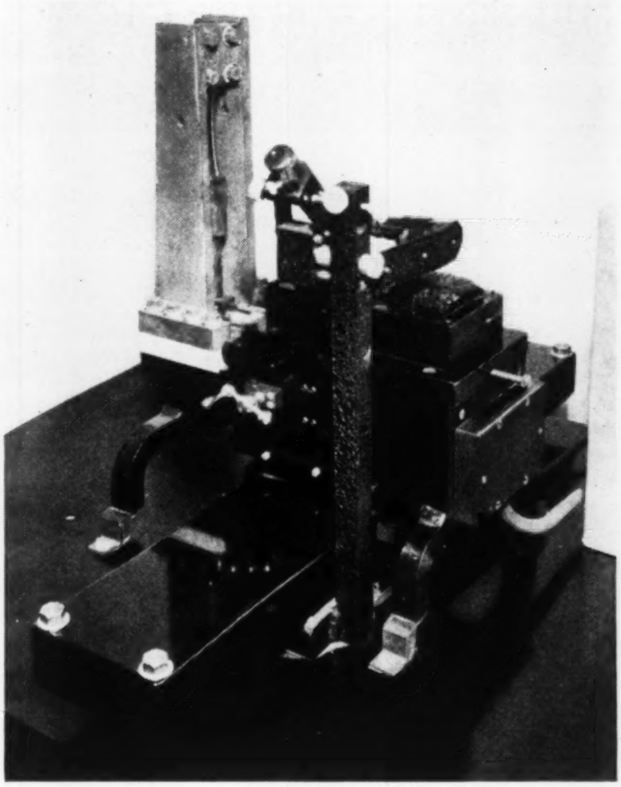

FIG. 9 BENDING-FATIGUE APPARATUS OF 120-CYCLE PERIOD

(Furnace around specimen, top left, has been removed; driving magnet and microscope to measure amplitudes shown in center.)

proper frequency. Thus, at any time during the test, the amount of energy fed into the vibrating system, which must equal the amount dissipated by damping, can readily be determined.

Problems come up in which it is impossible or impractical to vibrate the specimens at their natural frequency. As an example, if it is desired to apply a force to the blade to simulate the centrifugal force, it will usually be found that the necessary crigging makes vibration at high frequencies very difficult.

A powerful crank machine (Fig. 8) has been built in which the specimens are loaded by means of springs. This machine is used to vibrate blade specimens at high temperatures and in steam atmosphere, and the action of centrifugal forces is simulated by a pull on the specimen. It is particularly useful to study construction details such as impulse-blade roots.

Where a large number of tests have to be made on identical specimens, it is advantageous to have testing machines specialized for this purpose. Bending tests on a number of various blade materials at high temperatures are made in a battery of 120-cycle fatigue machines, Figs. 9 and 10. Standard specimens are used having a 120-cycle natural frequency. These specimens are driven with a slender rod moved by a 60-cycle magnet. The amplitude is accurately controlled by means of an ingenious vacuum-tube network developed by Messrs. Welch and Wilson. These machines are entirely automatic and independent of variations in the supply current. They shut themselves off when failure occurs. They have an advantage over the rotating cantilever machines in that the type of loading corresponds more nearly to that to which blades are subjected.

The foregoing description of fatigue-testing technique and its use in obtaining blade structures of optimum strength indicates the character of the work now being undertaken by the turbine builder to insure a rational design.

The research work which is described in this paper is being carried out in collaboration with R. E. Peterson and F. T. Hengstenberg of the Westinghouse research laboratories in East Pittsburgh, Pa., and C. C. Davenport, of the South Philadelphia Works.

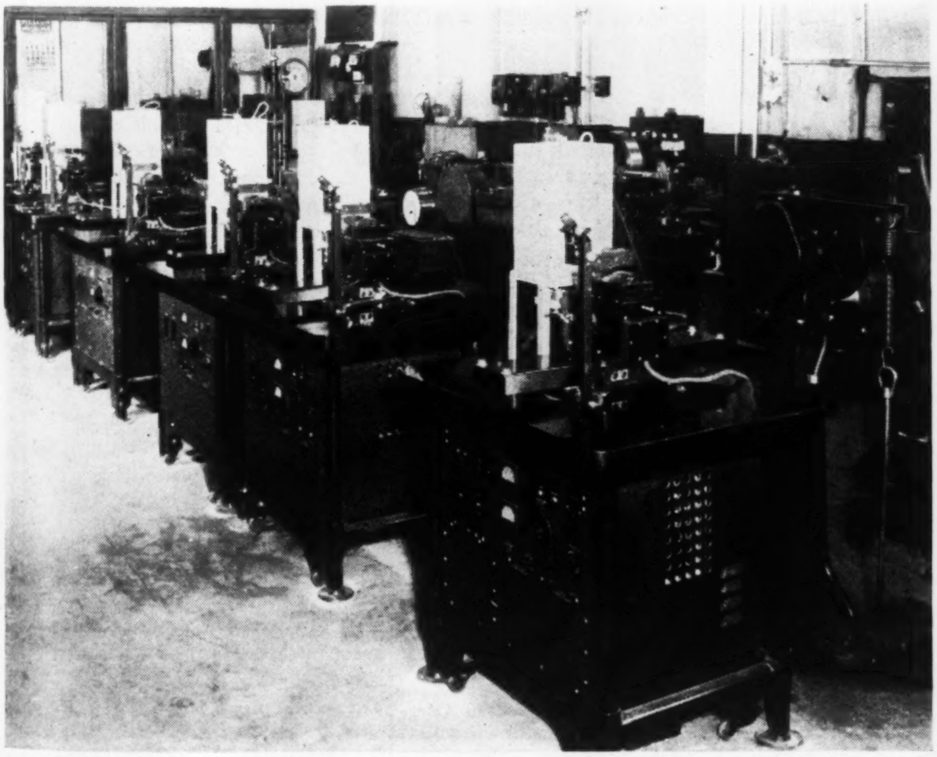

FIG. 10 BATTERY OF BENDING-FATIGUE MACHINES FOR HIGH-TEMPERATURE WORK

INTRODUCTION TO BUSINESS HISTORY[1]

By CHARLES W. MOORE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THERE are few books in the abundant literature of business and economics that greatly assist the reader to a mature and sophisticated understanding of the business world. This volume,[2] however, is notable among the few. Professor Gras describes it as an introduction to business history, a tentative beginning for a new science, and scholars will value it as such. But to the active executive and the student, its importance lies in the fact that it is a summary of the contributions of this new science to the interpretation of the current business scene.

"Business and Capitalism" covers the fields of business and economics for a period of approximately five thousand years. Beginning with the earliest fundamentals and the simplest conditions, the patterns of business development are enlarged and extended until they become the intricate design of our present-day economy. The dominant motif of this design is the superlative efficiency of financial capitalism in the coordination of economic effort, and the laudable uses of the power of money that characterized Big Business in the prosperous 'twenties. Behind this modern pattern are the business systems that dominated the ancient and more recent past, particularly the successive systems of capitalism that were ruled by the master workman, the merchant prince, and the captain of industry. In the near foreground are the outlines of a new variant of the old theme—national capitalism, the system of Roosevelt and Blum, of Hitler and Mussolini. The divergent ideologies of these leaders and the different ways of life that are followed by their respective nations make them seem completely different, but they are varied illustrations of a single trend—the age-old trend toward a broader coordination of economic effort and a greater concentration of economic power.

Although Professor Gras has produced a pithy survey of the field, the book is not recommended to the hasty reader. Its contents will not be revealed by skimming. For example, it is useless to turn to the section on Financial Capitalism in the hope of finding, at once, the description of the modern system of Big Business. This work is not a contrast of epochs—it is a comprehensive study in change and movement. One cannot begin to read this volume in the middle without losing much of its significance, for the exposition of each period of growth is largely in terms of the conditions which preceded it. It is these threads of logical development that give the work its conspicuous strength and clarity.

It would be reasonable to expect a study of such great scope to be brief and superficial, or thorough and dull, but the work is both brief and thorough—never dull. The presentation is rich in specific details which give the argument convincing force and lively interest. The details have been selected with great care from the accumulated results of decades of scholarly research, and they are presented in the vivid fashion that is the distinguishing mark of the inspired teacher. A sense of nearness and vitality is imparted by showing well-known things in a new light, and by correlating old ideas in fresh, distinctive patterns. The author always remains on ground that is in some degree familiar, yet he invariably creates an atmosphere of intellectual adventure. The reader is never required to struggle with the strange abstractions of the theoretical economist, nor to follow the practical businessman through a morass of detail, like a coolie plowing a rice paddy.

Critical analyses of capitalism often lean toward scathing denunciation and threatening prophecy, but here we have a constructive treatise written in an optimistic vein. The emphasis is on the progress that has been achieved under capitalism—the abuses of the system are only briefly mentioned and then dismissed as irrelevant to the purpose of the book. That purpose is to turn academic research and analysis into practical tools of executive action. It is necessary, of course, that the executive should know and avoid the abuses, but his major responsibilities are those of positive achievement. The businessman, like the politician and the social worker, knows all too well the evils of the system in which he operates, but the forces which lead to socially desirable results are imperfectly known, and their use in practice is very inadequately understood. The preponderance of attention to the favorable attributes of capitalism is dictated by the serious deficiency of keenly critical comment on this aspect of the subject.

Although the purpose for which the volume was written justifies the constructive attitude, it does not fully explain it. The text shows quite plainly the deep conviction on the part of Professor Gras that the system of private business capitalism is worthy of wholehearted approval—though not without some minor qualifications—and the defense of financial capitalism is particularly thorough and vigorous. Many readers will be unable to share the author's convictions, but they may note with satisfaction that he has not permitted his faith to corrupt the presentation of the facts, nor does he fail to respect the reader's privilege of drawing his own conclusions from the evidence offered. The major effect of the author's personal opinions is to lend color and enthusiasm to the text.

The scope of the subject and the great span of time make it difficult to preserve the unity of the study, but it has been done by limiting the discussion of historical material to those aspects which have a significant bearing on current problems. The unity of the work is further strengthened by adopting two specific objectives (p. viii), namely "to discover the main lines of development in *business policy* and the chief results of *business management* through the centuries and to correlate the two."

The result is a vivid and realistic record of the interdependent movements in business, economics, and politics. Any student of these subjects, regardless of his opinions on controversial issues, should find in this volume a major contribution to breadth of vision and depth of understanding.

* * *

The "Casebook"[3] provides the material for a more detailed study of representative enterprises and the men who led them. It was developed over a series of years for use by classes at the Harvard School of Business Administration and contains both factual details and local color in support of the general patterns

(*Continued on page 542*)

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[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Business and Capitalism: An Introduction to Business History," by N. S. B. Gras, F. S. Crofts & Co., New York, N. Y., 1939, $3.50.

[3] "Casebook in American Business History," by N. S. B. Gras and Henrietta M. Larson, F. S. Crofts & Co., New York, N. Y., 1939, $5.

KINEMATIC SYNTHESIS OF MECHANISMS

By A. E. R. de JONGE

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WHILE "kinematic analysis" has more or less become known in the English-speaking countries through F. Reuleaux' works,[1,2] practically nothing has appeared there in print on the subject of the "kinematic synthesis of mechanisms." Recently, a paper was published in Mechanical Engineering by C. Thumin,[3] on "Quick-Acting Release Latches" for electric circuit breakers, which is particularly well adapted to illustrate the use of kinematic synthesis for developing all types of mechanisms for a given purpose. The author has, therefore, chosen that paper as a basis for the following remarks.

In his paper,[3] Mr. Thumim has presented a clear and easily understandable exposition of the subject of quick-acting release latches. In common with the entire electrical-engineering profession, he uses the term "latch" in a rather loose sense which runs counter to concepts established long ago by Reuleaux in the theory of mechanisms.

One also cannot fail but be impressed by the lack of clarity with regard to the fundamental types of mechanisms frequently encountered in the technical literature in general, and even in the files of the Patent Office. A clear knowledge of these fundamental types is, however, important to every engineer, and it is, therefore, proposed to discuss in the first part of what follows, the classification of those types of mechanisms which are not generally treated in the textbooks on mechanisms.

According to Mr. Thumim in the paper cited, "the latch may be defined as a mechanical device which will hold securely under *any* set of predetermined conditions and which will release with equal reliability under another set of circumstances." It would probably be better to say "*one* set" instead of "*any* set," but even with this restriction, the definition given is, obviously, too broad, for it embraces also locks, brakes, escapements, and similar devices.

It is not surprising that a more exact definition for the devices described could not be given, for the latter belong to the vast class of intermittently acting devices generally not well known. To this author's knowledge, there exists no textbook on kinematics or on the theory of mechanisms, written in the English language, which gives a classification of these devices. The only classification established so far is that by F. Reuleaux, of Germany, the well-known originator of the modern theory of mechanism.[2,4] His classification of these devices, which was the result of careful investigations, is unsurpassed even today, after more than fifty years. Since few English-speaking engineers are familiar with this classification, it is necessary to start with a brief review of it so as to make clear the concepts created thereby.

Reuleaux has given this class of mechanisms and its six subclasses definite names, but unfortunately these German terms do not lend themselves readily to a translation into the English language.[5] Hence, the author has coined, in part, new and more appropriate English terms for them. These terms have been selected with great care and have already been used by him for years in courses on mechanisms at the Polytechnic Institute of Brooklyn. They have, thus, become the property of a steadily increasing number of engineers and should not be replaced by other terms unless special reasons for such action can be presented.

A NEW TERMINOLOGY

As a class, the author calls all intermittently acting devices ***intermittors***.

While in continuously moving devices the sense of the steady driving force, or moment, has no influence on the nature of the motion produced, it is of prime importance in intermittors in which it determines the nature of the motion of the principal moving member. Since this member is brought to a standstill for brief or lengthy periods by some other member, or is "blocked" by it, the principal member is called the ***blocked piece***, and the member bringing it to a standstill the ***blocking piece***, or ***arrestor***, sometimes also by other and more specific names. While the device in conjunction with the acting forces is called an intermittor, the device itself without regard to these forces is called a ***blockage*** or ***block train***. All intermittors therefore contain blockages. Because the steady force acting on the blocked piece drives, or tends to drive, the latter, intermittors are also called ***block drives***, and the driving force acting on the blocked piece, the ***blockage force***.

Intermittors are subdivided into six subclasses. These, however, may be grouped in two groups of three subclasses each:

(*A*) Devices which make motion of the blocked piece temporarily impossible, or ***statomotors***.

(*B*) Devices which let motion of the blocked piece temporarily occur, or ***motostators***.

The subclasses are easily recognizable as the term "gear" has been added to the characterizing term.

The subclasses and their characteristics are:

Group *A*

1 *Blocking gear*, for the sole purpose of preventing motion of the principal member in the sense of the blockage force. The arrestor, in this case, is termed a ***click*** or ***pawl*** (Fig. 1). Examples: Pawls in winches, lifting, and hoisting gear.

2 *Checking gear*, for arresting the principal member when in motion under the influence of the blockage force (Fig. 2). Examples: Brakes and other arresting gear.

3 *Locking gear*, for producing temporarily a resistant, but easily disconnectable connection (Fig. 3). Examples: Door locks, latches, window locks, safety catches on guns, electric switches, couplings.

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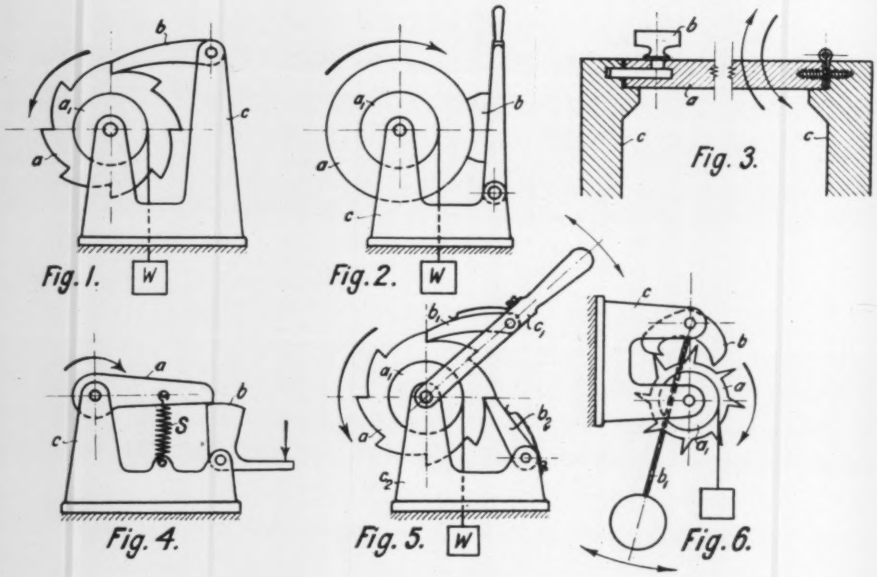
[1] "Kinematics of Machinery," by F. Reuleaux, translated into English by A. B. W. Kennedy, Macmillan & Co., London, 1876.

[2] "The Constructor," by F. Reuleaux, translated from the fourth German edition by H. H. Suplee, 1894.

[3] "Quick-Acting Release Latches," by C. Thumim, Mechanical Engineering, November, 1939, pp. 807–812.

[4] "Theoretische Kinematik," by F Reuleaux, vol. 2, 1900.

[5] Compare the attempt made by H. H. Suplee in translating Reuleaux' "Konstrukteur," see footnote 2.



INTERMITTORS

GROUP "A" (FIGS. 1, 2, AND 3) MAKE MOTION TEMPORARILY IMPOSSIBLE.
GROUP "B" (FIGS. 4, 5, AND 6) LET MOTION TEMPORARILY OCCUR
(Fig. 1 Blocking gear. Fig. 2 Checking gear. Fig. 3 Locking gear. Fig. 4 Release gear. Fig. 5 Feed or ratchet gear. Fig. 6 Escape gear or escapements.)

Group *B*

4 *Release gear*, for suddenly, at the intended instant, releasing stored energy (Fig. 4). Examples: Trigger gear of guns, rifles, rams, and certain steam-engine valve gear, tripping gear.

5 *Feed gear*, or *ratchet gear*, for the stepwise overcoming of the blockage force (Fig. 5). Examples: Ratchets on hand drills, drill presses, planing machines, etc., and valve pumps.

6 *Escape gear*, or *escapements*, for letting the blockage force come stepwise into action thereby moving the principal member in its sense (Fig. 6). Examples: Clock and watch escapements, steam-engine valve gear.

It is now easy to classify correctly the devices described in Mr. Thumim's paper. It will be obvious that latches in the commonly accepted sense belong to the third class, or *locking gear*, while the devices described in it belong to the fourth class, or *release gear*. There is a distinct difference between these two. In locking gear, the blocked piece cannot move in either sense of its only degree of freedom to motion, but in release gear, in which the blocking piece likewise arrests the blocked piece, the blocked piece may, although it does not need to, move in one sense, namely, in that opposite to the action of the force produced by the stored-up energy, in the present case against the action of the spring. Thus, it is wrong to call the part which blocks the motion of the principal member in the circuit breaker, namely, the *trigger*, a latch, as was done in the paper referred to, and Mr. Thumim has apparently felt that this is not the correct term, for at many places he calls it a *prop*, and at others a *hook*.

There is, therefore, no locking in the proper sense, but only retention until the stored energy is suddenly released. It is therefore wrong to speak of locking a circuit-breaker gear. It is solely a cocking action like in the case of a gun.

TYPES OF RELEASE GEAR ANALYZED

We shall now try to derive all the different types of *cocking devices* or *triggers* which may possibly perform the function expected from them in electric circuit breakers.

To investigate this question, it is necessary to make use of what is called *kinematic analysis* and *kinematic synthesis*.

In the closed position of the switch, the cocked release gear represents, in the sense of the acting impressed force, an immovable three-link kinematic chain, the three links being lever *a* of the circuit breaker linkage, lever *c* of the trigger, and frame *d* containing the two fulcrums 1 and 4 (Fig. 7). Such a chain is called an *excessively closed chain*, or a *locked* chain, as its links cannot perform any motion relative to one another in the sense of the force acting on lever *a*. In order that lever *a* may move when the circuit breaker is to break the current, this three-link chain must be made movable. This can be accomplished in several ways for, by the use of continuously moving devices, movable mechanisms may be derived from it.

According to Reuleaux, the various classes of continuously moving devices are: (1) Screw trains; (2) crank trains, or linkages; (3) wheel trains; (4) cam trains; (5) belt trains. To these classes may be added certain blockages containing a fluid as one of their members, i.e., certain (6) fluid trains. With the exception of class 5, or belt trains, all other classes may be used to derive release gear from the locked kinematic chain.

On account of limitations in space, it is out of the question to give here a complete synthesis of all the forms possible as this would greatly exceed the scope of this article. From these possible forms would then have to be deducted those which, for some reasons, are impracticable, to obtain the entire number of practicable solutions. Nevertheless, an idea will here be given how such an investigation may be carried out, by selecting a few examples from each of the foregoing five applicable classes of mechanisms, but without going into detail as to how these types can actually be used in the circuit breaker.

USE OF SCREW TRAINS

Let us start with screw trains. By substituting for link *c*, Fig. 7, a screw spindle *c*, Fig. 8, it becomes necessary, in order that this spindle can turn, to provide at 2 and 4 hinged prisms *b* and c_1, of which *b* forms the nut while c_1 forms a bearing for the spindle. Prism *b* can thus advance when the spindle is turned by the lever attached to its top. The mechanism $abcc_1d$ with the points of pairing 1, 2, 3, 3*a*, 4 is a movable screw train. Such a mechanism, however, would not be suitable for release gear unless the pitch of the screw threads were large. If we now go to the limit, i.e., if we make the pitch infinitely large, the screw threads become splines which engage with grooves in prism *b*, the former nut. By cutting off the screw threads, i.e., the splines, for a certain length (Fig. 9), it would become possible to pull the prism up on the spindle until the splines leave their grooves. If the spindle then be turned slightly, prism *b* could not move down on the spindle even though a spring *S* tends to force lever *a* downward (see section *A–A*, Fig. 9). When the spindle is turned back, however, for example by a tripping coil, until the splines again engage the grooves, lever *a* would suddenly be free to move downward under the influence of the spring. The entire mechanism thus becomes a release gear. It goes without saying that this form would not be the best and simplest to use for this purpose. Actually, a whole series of solutions may be derived therefrom, all of which can be systematically obtained by apply-

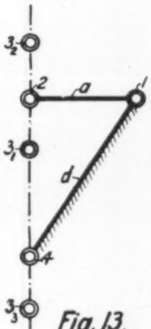
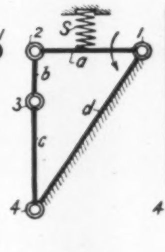


Fig. 13.



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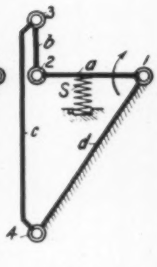

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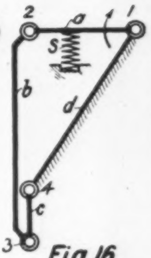

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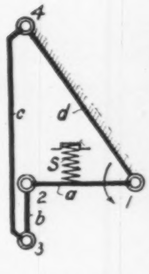


Fig. 15a.

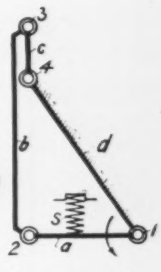
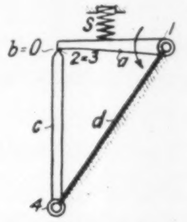


Fig. 16a.



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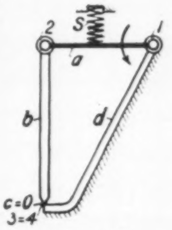


Fig. 18.

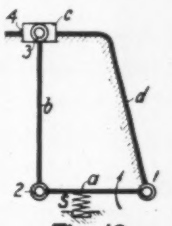


Fig. 19.

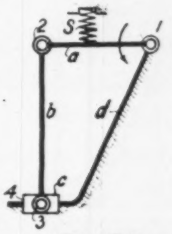


Fig. 20.

ing the laws of kinematic variation.

Thus Fig. 10 shows the screw spindle reduced to a lever *c*, movable between two adjustable stops which limit the motion. Lever *a* contains one of the grooves for the remnant of the spline. In Fig. 11, we see that the diameter of the screw spindle has become infinitely large so that only part of it can be executed. This part becomes a flat strip supported by brackets on the frame by the intermediary of steel balls running in grooves, to reduce friction to a minimum.

In both cases, lever *a* rests with a flat surface on a flat surface of *c*, both of which are easy to manufacture. These two cases therefore represent practicable solutions.

Fig. 12, finally, shows a "counter-duplication" of the lever *c* of Fig. 10-levers c_1 and c_2 both being hinged on the same pin like a pair of tongs, or on separate parallel pins. At their one end, which is suitably cut out to allow lever *a* to pass between them when in the open position, lever *a* rests with a flat surface on flat surfaces. Opening of the tong-like levers c_1 and c_2 is accomplished by means of a roller on the tripping plunger, or, better still, by means of a pair of toggle levers e_1 and e_2. Springs S_1 and S_2 push the toggle levers back into their original position. Return of lever *a* to the cocked position is accomplished in this case as in those shown in Figs. 10 and 11 by suitably shaping the upper end of lever *a*, sections *A–A* in Figs. 11 and 12. These three types represent practicable solutions although the introduction of rollers at the end of lever *a*, or on *c*, and some further slight modifications would be necessary to adapt them to the purpose in question.

These are a few of the many possible forms based on screw trains.

USE OF CRANK TRAINS OR LINKAGES

We come now to the application of the second class of mechanisms, namely, *crank trains or linkages*, for making the locked chain of Fig. 7 movable. A four-link chain[6] will have to be used for this purpose as it is the only constrained movable elementary link chain. It goes without saying that compound chains too may be employed, but these result in more complicated mechanisms. To keep lever *a* in a fixed position, the four-link chain must be used in the so-called "dead point" or "stretched" positions; Fig. 13 shows that link *c* of Fig. 7 may be replaced by two links, the common joint of which must lie on the line 2–4. The choice of the location of this hinge 3 is still free, and it is obvious that 3 can be chosen either between points 2 and 4, as in 3_1, or outside 2–4 on the side beyond 2, as in 3_2, or on that beyond 4, as in 3_3. Thus, three typical elementary mechanisms are obtained which, respectively, are shown in Figs. 14, 15, and 16. It should be mentioned that in these figures skeleton diagrams are shown for the sake of simplicity. Lever *a* in Fig. 14 turns counterclockwise while in Figs. 15 and 16 it turns clockwise. Figs. 15*a* and 16*a* show these latter two mechanisms reversed so that lever *a* again turns counterclockwise.

Further and singular solutions are those in which joint 3 coincides with either joint 2 or joint 4. In the first case, link *b* = 0, and in the second case, link *c* = 0. These solutions are represented in Figs.

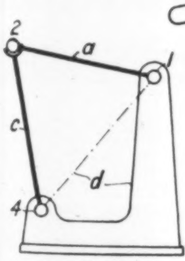
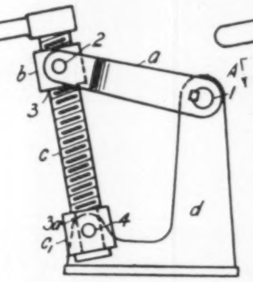


Fig. 7.



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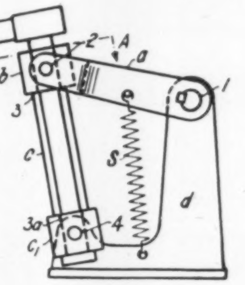

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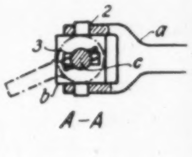

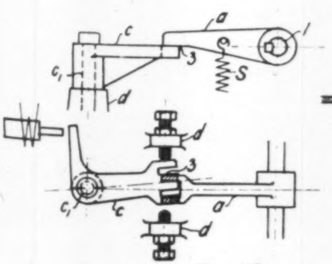

Fig. 10.

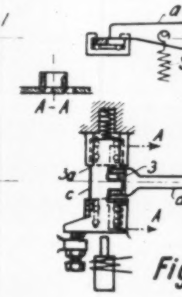

Fig. 11.

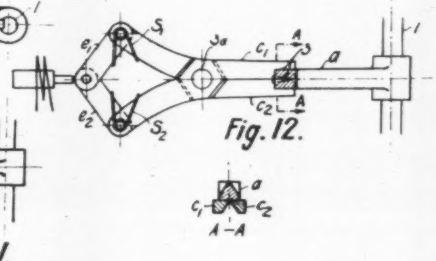

Fig. 12.

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[6] Sometimes called "quadric-link chain" or "hinged four-bar linkage."

17 and 18, respectively. Both solutions can be made use of in practice if an auxiliary trigger is used as will be shown later. Point 3 cannot be located at infinity, because the range limit of 3 is defined by $b + c \leqq a + d$ for both cases shown in Figs. 15*a* and 16*a*. However, joint 4 of Fig. 15*a* as well as joint 3 of Fig. 16*a* may be located at infinity. In the former case, the mechanism of Fig. 19 results and, in the second case, that of Fig. 20. As is evident, both are identical. However, they cannot be used directly, but have to be modified as will be shown later (Figs. 30 to 36).

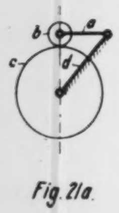


Fig. 21a.

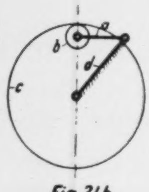


Fig. 21b.

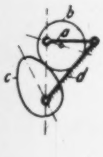


Fig. 21c.

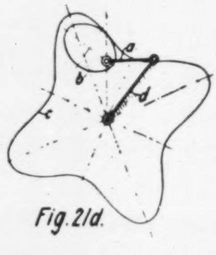


Fig. 21d.

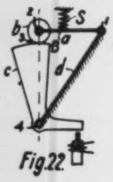
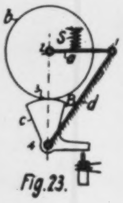


Fig. 22



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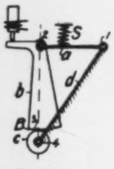

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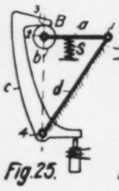

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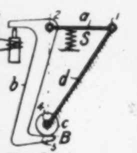

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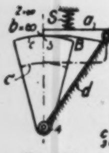
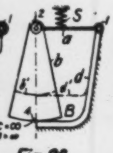


Fig. 27.



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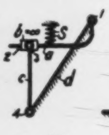


Fig. 29

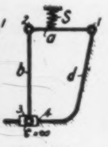
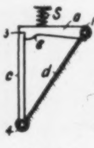


Fig. 30.



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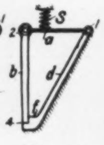

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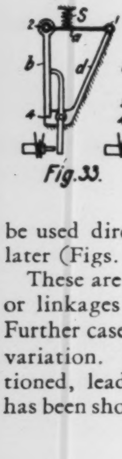

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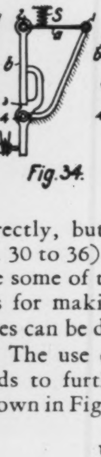

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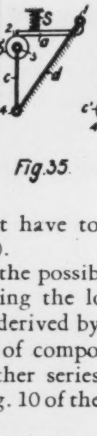

Fig. 35

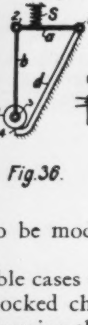

Fig. 36.

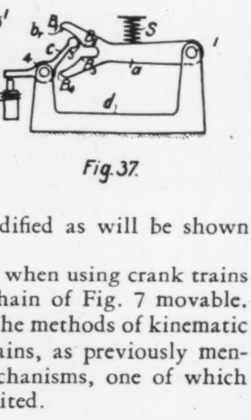

Fig. 37.

These are some of the possible cases when using crank trains or linkages for making the locked chain of Fig. 7 movable. Further cases can be derived by using the methods of kinematic variation. The use of compound chains, as previously mentioned, leads to further series of mechanisms, one of which has been shown in Fig. 10 of the paper cited.

USE OF WHEEL TRAINS

The third manner of making the locked kinematic chain of Fig. 7 movable involves *wheel trains*. If point 3 in Fig. 13 be considered not as a hinged joint between two links, but as the point of contact of two higher-element pairs, a wheel train results. Strictly speaking, distinction should be made between *friction wheels* and *gear wheels*. There is, however, no difference between them if the roll-curves are considered. The only difference is that the teeth of gear wheels have finite dimensions while those of friction wheels are almost infinitely small. The simplest roll-curves are, of course, circles, but roll-curves are not limited inherently to circles, for any other roll-curves may be used as long as, in the cocked position of lever *a*, the sum of the radii vectors to their point of contact is equal to the length of link *c* of the locked chain of Fig. 7. Naturally, in order to make the chain suddenly movable, there must be a discontinuity in at least one of the roll-curves. This can be brought about by simply breaking off the roll-curve at a certain point *B*. Figs. 21*a*, *b*, *c*, and *d* show various forms of roll-curves, Figs. 21*a* and *b* circles with external and internal contact, Figs. 21*c* and *d* any roll-curves likewise with external and internal contact. Figs. 22, 23, and 24 show release gears based on circles with various positions of the point of contact 3 on line 2–4, only those of Figs. 22 and 24 being usable. The mechanism of Fig. 25 utilizes circles with internal contact in a point beyond joint 2, and that of Fig. 26 circles with internal contact beyond joint 4. In all these cases, one of the roll-curves is discontinued at a point *B* so that, at this point, the mechanism becomes movable under the influence of the impressed force of spring *S*. Similar conditions prevail in the case of irregularly shaped roll-curves, or for such provided with teeth.

A few special cases may here be considered. Fig. 27 shows the case, in which the radius of wheel *b* becomes infinitely large ($b = \infty$), and in which rolling friction has been replaced by sliding friction. In this case, lever *a* simply touches wheel *c*. The same holds true for any parallel line *a′* to *a* which would touch a wheel *c′* concentric with *c*.

Fig. 28 shows the case where wheel *c* becomes infinitely large ($c = \infty$) and *b* slides over a straight line attached to the frame until discontinuity *B* makes the train movable. The same holds for any parallel line *d′* to *d* connected to the frame, and a circle *b′* concentric with *b*.

If wheel *c*, Fig. 27, becomes an infinitely narrow sector, i.e., approaches a straight line of finite length, the mechanism of Fig. 29 results. Similarly, if *b*, in Fig. 28, becomes a straight line of finite length, the mechanism of Fig. 30 is obtained. While these two cannot be used directly in the form shown, they can be adapted for use in a circuit breaker by arranging a stop *e* on lever *a* as shown in Fig. 31, or a stop *f* on frame *d* as shown in Fig. 32. In these cases, it is appropriate to add a separate trip as an auxiliary trigger as has already been mentioned before. Fig. 33 shows this arrangement for the device of Fig. 32. The same auxiliary trigger can be applied to the case of Fig. 24 if both wheels become narrow sectors as indicated in Fig. 34. By introducing a higher-element pair, namely, circle and straight line, the mechanisms of Figs. 29 and 30 assume the shape of those shown in Figs. 35 and 36.

In all these cases, friction wheels have been assumed, but there is no inherent difference if wheels having the same roll-curves would be provided with gear teeth as has been stated previously.

It should be mentioned that in the case of any other roll-curves, in which the sum of the radii vectors is equal to the center distance of the wheels, slipping would result if the angle made by the common tangent with the common center line becomes too small. In that case, gear teeth would have to be introduced to prevent such slipping and to make the train constrained movable.

There is, however, one important case, namely, that in which the radius of wheel *b* becomes zero while wheel *c* is reduced to a single tooth which works directly in a gap of lever *a*. Fig. 37 shows this arrangement. As long as tooth *c* travels with its outer edge along circle B_1B_2, no movement of lever *a* takes place. When, however, tooth *c* enters gap B_2B_3, motion becomes possible and wheel *c* is being driven by lever *a* under the action of spring *S* until lever *a* comes to a stop. If tooth *c* would then travel along circle B_3B_4, lever *a* would be arrested in the lower position, and, upon turning tooth *c* back into the original position, lever *a* would, again, be lifted into the original cocked position. This mechanism resembles that of a key and latch in a lock, the only difference being that, in a lock, the key moves latch *a* while, in this case, lever *a* moves the key *c* from the moment the tooth enters gap B_2B_3. This case shows, probably clearer than any other, the inherent difference between locking gear and release gear.

USE OF CAM TRAINS

The last class of continuously movable mechanisms that can be applied to making the locked chain of Fig. 7 movable are *cam trains*.

If wheel *b* in Fig. 22 be reduced to zero, and if lever *a* does not slide along the curve of wheel *c*, but touches this curve with a single point 3 only, a cam train results. As long as wheel *c* is circular, no motion of *a* takes place. At any discontinuity of wheel *c*, lever *a* would immediately become free to follow the action of spring *S*. This case is shown in Fig. 38. If the curve of wheel *c* is not a circle about 4 as the center, but any other curve, some motion of *a* in the sense of spring force *S*, or in the opposite sense to it, results before lever *a* becomes free at the discontinuity of wheel *c*. Fig. 39 shows a similar cam train with internal contact. Fig. 40 illustrates the inversion of element pair 2, the point being attached to lever *c* while the curve is attached to lever *a*. Fig. 41 shows a similar inversion of pair 2 in the case of internal contact.

If in these cam trains the sharp point of the cam follower (levers *a* or *c*) be expanded into a roller, we obtain, respectively, the cases shown in Figs. 42, 43, 44, and 45. Fig. 42 depicts the same mechanism as Fig. 22. In this case, the cam train reverts to a wheel train. Fig. 43 shows that the mechanism of Fig. 39 becomes the same as that of Fig. 25, for the same reason. These cases represent some, but by no means all, of the cam trains possible.

The fifth class of *belt trains* cannot be used in the case under discussion, because the belt, of necessity, is a continuous body and cannot have any discontinuity which is necessary to make the mechanism of the locked chain, Fig. 7, movable.

USE OF FLUID TRAINS

Of purely mechanical devices, there remain to be discussed certain blockages which contain a fluid as one of their members, i.e., certain *fluid trains*. Only two examples will here be given. Fig. 46 represents a cylinder and piston, the piston being subjected to compressed air. The tripping device actuates a valve admitting compressed air from a storage tank, thus rapidly moving the piston and thereby lever *a*. Such a fluid train is, for instance, used in the high-tension oil circuit breakers[7] constructed by the Metropolitan Vickers Electrical Company, Ltd., Manchester, England. Fig. 47 shows the case of a chamber train being used for the same purpose, lever *a* forming the piston of this chamber train. Control of the compressed air is again effected by a valve of either the piston-valve or poppet-valve type, actuated by an electromagnetic tripping device.

In the cases discussed, the force acting on lever *a* was provided by the elasticity of a spring or a gas (compressed air). The question arises as to whether any other type of force of sufficient magnitude is available. Of all other forces met with in nature, so far only one is known to be sufficiently powerful for the use in electrical circuit breakers, namely, electromagnetic force. Furthermore, the electromagnetic force and thermal expansion may be used as tripping forces.

In Figs. 5*a* to *d* of Mr. Thumim's paper, a few of the possible forms using electromagnetic force are illustrated, namely, the ordinary electromagnet type and the flux-diverter type, and these may suffice here as examples of this type of force. Others may be designed by using different types of circuits for both, the magnetic lines of force and the exciting electric current. It must, however, be kept in mind that the mechanical devices involved are the same as those here described, and that the electromagnet supplies only the force holding lever *a* in the cocked position thus replacing link *c*, of Fig. 7, and counteracting the elastic force which acts directly on lever *a*, or supplies the force necessary for tripping the mechanical release gear. Finally, by using an electromagnetic coil and movable core, the electromagnetic force may also be used for moving lever *a* directly. That, in the case in which only a small tripping energy is available, recourse has to be taken to more complicated devices, has been well illustrated by the impact trip mechanism shown in Figs. 12 and 13 of Mr. Thumim's paper.

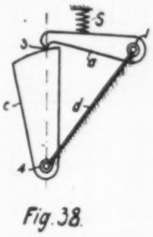

Fig. 38

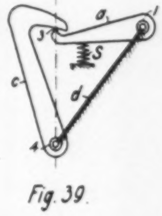

Fig. 39

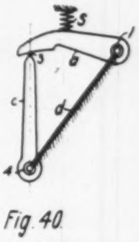

Fig. 40

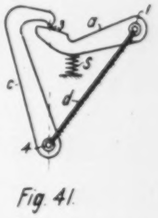

Fig. 41

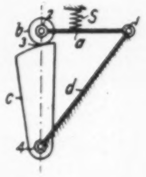

Fig. 42

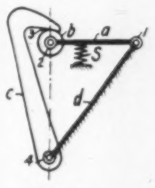

Fig. 43

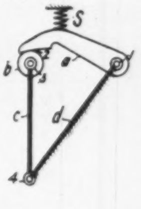

Fig. 44

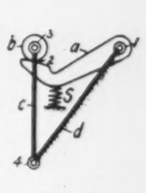

Fig. 45

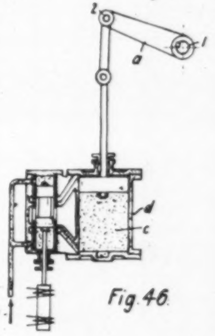

Fig. 46

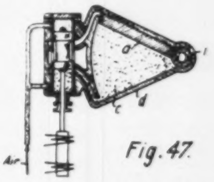

Fig. 47

Devices using the last force that may be employed for tripping the release gear, namely, thermal expansion, have also been shown and described in that paper (Figs. 15*a* and *b*). Naturally, these do not represent all the cases possible, but they may suffice.

For the applicability of the various link mechanisms (toggle levers), it is necessary, to start with, that they be in a position of stable equilibrium. In the positions shown here by the author, that is, in their dead-point configurations, they are in unstable equilibrium. It is, therefore, necessary to move the links from their dead-point position into a position beyond it, or into an "overdead-point" position. For this reason, it is incorrect to call this position an "overcenter" position as was done in Mr. Thumim's paper. As will be clear from the foregoing, the terms used in that paper, namely "dead-center latches," "overcenter toggles," and "overcenter surface latches" should be replaced by "wheel triggers," "overdead-point toggles," and "cam triggers," respectively. To these would have to be added "screw-gear triggers," and "fluid-gear triggers," which, together with "electromagnetic triggers" and "thermal triggers" represent the various types. These terms describe more accurately the nature of the various devices than do those used in the paper cited.

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[7] "High-Tension Circuit Breakers," *Engineering*, June 16, 1939, pp. 709 to 711.

The remarks of Mr. Thumim as to a latch (meaning obviously the entire release mechanism) being a force-reducing mechanism, of which two types are illustrated in his Figs. 10*a* and *b*, are interesting. From the standpoint of kinematics, these forms are six-link chains, one of the links of which is reduced to zero by the introduction of a higher-element pair. As stated before, many other mechanisms can be developed from compound chains, of which the six-link chain is one.

The discussion of shock forces by Mr. Thumim, and the location of the shock-producing electromagnetic tripping coil and plunger at right angles to the motion of the trigger are important considerations in the layout of circuit breakers. The devices of Figs. 10, 11, and 12 shown here should, therefore, prove particularly attractive.

It is naturally impossible here to subject all the practically suitable mechanisms to considerations of practical operation and manufacture. It should be stated however, that in many respects wheel triggers have advantages over toggle and cam triggers, a fact which has already been mentioned in Mr. Thumim's paper. However, fluid gear triggers, which were not discussed in it, also have decided advantages, as exemplified by the Metropolitan Vickers Electrical Company's construction.

VALUE OF KINEMATIC SYNTHESIS AND BRANCHES OF THIS SCIENCE

It will be seen from the foregoing that Mr. Thumim has, by no means, described all practicable cases and certainly not all possible cases. His arbitrarily chosen four types (called classes by him) have afforded the author the opportunity of showing here the inner relations which actually exist between the various types and forms. While this constitutes kinematic analysis, the establishment of all existing types and forms constitutes what is called *kinematic synthesis* and, more specifically, the branch which concerns itself with the various types only, *type synthesis*. The value of such type synthesis should be apparent to all designing engineers and, particularly, to those who are charged with safeguarding constructions by patents. In that case, it is essential to state *all* possible constructions, and, to this end, type synthesis furnishes the basis. Its knowledge should also prove invaluable to patent examiners and patent attorneys.

A second branch of kinematic synthesis used for amplifying and checking type synthesis is that which concerns itself with the relations between the number of element pairs, the number of members, and the constrained movability of kinematic chains. This synthesis is called *number synthesis*.

Finally, after the various types of mechanisms have been found, their most suitable forms must be determined. As these depend on the principal dimensions of the various members, that is, on their relative sizes, this kind of investigation is called "size synthesis." This third branch, which is used for creating mechanisms to suit given conditions by determining the forms and required sizes of their members, is, undoubtedly, the most difficult one of kinematic synthesis.

As a means of determining the suitability of a mechanism for the particular purpose under consideration, an analysis of it with respect to velocities, accelerations, the forces acting on its members, and their influence on the dynamic behavior of the mechanism is required. Mr. Thumim has felt the necessity for such an analysis of, at least, the forces, for he has determined the static forces which are acting in the various cases he has described. Space does not permit here of extending his investigation to all other practicable mechanisms described in the present paper. Such an investigation must, however, form an essential part of the investigation of release devices for electric circuit breakers, as it gives an insight into their sensitivity to and their behavior in tripping.

To give here an outline of the other two branches of kinematic synthesis, number synthesis and size synthesis, is obviously not possible, as both involve elaborate and extensive mathematical analysis. The author, however, thought this a fitting opportunity for drawing attention to this hardly known field of kinematic science by explaining, for the first time, how at least the various types of mechanisms for a specific case may be systematically arrived at. If he should be successful in arousing a greater interest in the application of and in further research in kinematic science, he will feel himself richly rewarded for this modest effort.

Introduction to Business History

(*Continued from page 536*)

that are discussed in "Business and Capitalism." The material consists of anecdote, narrative, and statistics, with a few chapters which correlate the cases with the general economic and political background. Although primarily concerned with American business, European cases have been used where they disclose the roots of movements that were a later feature of the American scene.

The individual cases have been written not merely to furnish actual evidence of historical patterns, but with an eye to dramatic illustration. The struggles of the Virginia Company, the romantic career of John Law, and the reckless adventures of William Duer serve to fix in the mind of the student the major business movements to which these names are attached. In the later periods, such men as Morgan, Vanderbilt, and Hugo Stinnes are used to introduce the great changes in which they played a prominent part. The emphasis, however, is not upon men, but on the course of economic events and the methods by which they were brought to pass. These cases are studies in motives, action, and results.

Toward the close of the "Casebook" there are four chapters on "Secular Trends in Business History" which are devoted to a broad development of the theory of the Kondratieff cycle (the fifty-year business cycle). The importance of this section of the book is difficult to appraise. It has the great merit of treating a very complex problem in economic theory with commendable simplicity and brevity. It presents a survey of the figures on the subject that are customarily offered by the statistical economist, and it also takes into account the intangible factors with which businessmen habitually deal. It is conceivable that the movements of the Kondratieff cycle will eventually influence the formulation of long-run business policy quite as much as the short cycle now influences the solution of short-term problems. Many business disasters have resulted from basic errors in policy which were made for the sake of small immediate gains. The chapters on the Kondratieff cycle suggest a method of analysis that may reduce the frequency and amplitude of such errors. While the practical value of the method remains to be proved in the future, stimulating character of the discussion is a matter for more immediate enjoyment.

The RIGHTS *of an* INVENTOR-EMPLOYEE

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THE object of this paper is to indicate the respective rights of employer and employee with regard to inventions made during the usual course of employment. Large corporations invariably require new research employees to sign a printed contract setting forth the exact conditions under which the employee must assign patent rights. But many small organizations make no such provisions, in which case an employee has a legal right to obtain a patent for work done in the regular course of his employment and sell it to a business rival of the employer. An exception is when an employee is hired to invent the particular thing for which he obtained a patent.

Inasmuch as a contract to change the normal order of the passing of legal title is itself perfectly legal, as is a contract to pay royalties where a free license or shop right would otherwise apply, many of the usual misunderstandings can be avoided by a simple written agreement. This should set forth under just what conditions the employee should have all rights to an invention, under what conditions the employer should have a shop right only, and under what conditions the employer should obtain the full right, title, and interest.

These employment contracts, if clearly made in good faith, may be enforced in part even though invalid in some other part. For example, while a contract requiring an employee to assign all inventions of every kind to the employer for an unlimited period, irrespective of employment, would obviously be void as against public policy, yet if the agreement were a document in which such requirements could be separated so as to leave the remainder of the contract valid, the courts might divide the contract and hold the employee bound by the valid provisions.

My advice to employers generally is to make the contract somewhat far-reaching but to keep the period after employment reasonably short. One year should be ample under the recently changed statutes. Also, the inventions should be limited to those normally useful in the particular business.

DEFINITIONS

A patent is a grant by the government of the right to set the terms under which others may practice an invention. These terms may be so mild that many will accept them or they may purposely be made so burdensome that no matter how valuable the invention may be, it will remain unused during the entire life of the grant. To assign is to part with a portion or all of the title to a patent. To license is to give the right to make or to use or to sell or all three, but short of change in title. A shop right is a personal limited license usually obtained by an implied rather than an oral or written agreement.

More specifically, a patent is a grant under the constitutional provision whereby Congress was given the power to promote the progress of science by securing for limited times to inventors the exclusive rights to their respective discoveries. Although often so characterized, a patent should not be thought of as a monopoly, for it is created neither at the expense, nor to the prejudice, of all the community except its owner; rather it should be looked upon as a contract between the government and the inventor whereby in exchange for a seventeen-year right to exclude others, he dedicates his invention to the public at the end of that term, and gives such a clear and complete disclosure as to enable a skilled worker in that art to make full use of it without further instructions.

An assignment is an instrument, invariably in writing, conveying all three rights under the patent to all of the United States or to some designated geographical portion thereof. The three rights are the right to make, the right to use, and the right to sell, and if any one of these rights is curtailed the transfer is not an assignment and title does not pass.

A license is a transfer of one or more privileges under the patent short of an assignment. It may be oral, but if it is written or printed it must be duly signed. To insure clarity, it might be well to recall that in absence of a state law to the contrary a signed agreement may *not* be varied by oral understandings agreed upon either at, before, or after the signing, although sometimes the verbal modifying agreement may be separately enforced. Where an implied free license will attach or has already been created, a contract to pay for that license seems quite legal and may be enforced.

The privilege of continuing to use and to sell, after the grant of a patent, that which one has made with the knowledge and consent of the inventor before the filing of his application for patent is a statutory right. A shop right differs from it in that under a shop right the employer may not only continue to use and to sell the specific objects previously made but may manufacture others with the same privileges of use and sale and may increase the production to an extent commensurate with the growth of his business. Hence, if an employee invents a machine to practice a process, the employer not only may continue to use that one machine but the shop right would extend to as many of the improved machines to be constructed by the employer as are reasonably required for his business.

THE EMPLOYER-EMPLOYEE DOCTRINE

About 70 years ago the Supreme Court decided that an employer, having conceived the outline of an invention and being engaged in experiments to perfect it, is not to be deprived of the exclusive property in the perfected improvement by reason of suggestions from employees unless such suggestions amount to a new method or arrangement or unless they go to make up a complete and perfect machine, embracing the substance of all that which makes the invention patentable.[1] An example of the exception is the case in which one conceives the idea that if a material having certain desirable properties could be obtained it would make a better article than would the materials then in use and accordingly instructs an employee to produce such new material. Here a patent in the employer's name would not be valid because the entire patentable invention would be

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Presented at a meeting, Jan. 26, 1940, of the Anthracite-Lehigh Valley Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] Agawam vs. Jordan, 74 U. S. 583 (1869).

the discovery of the employee and the employer had supplied the problem but no suggestion for its solution.[2]

This doctrine may not be invoked unless the employer can prove his prior possession of at least the broad idea of the invention involved plus a disclosure to the employee. The rule today is less often applied because of the present necessity to patent details rather than complete machines.

That this doctrine has lost none of its virility is shown by a recent sewage case[3] and an opinion[4] by the Supreme Court 20 years ago holding that patentees do not lose their right to be considered the original discoverers of a patented process because an employee of theirs happened to make the analyses and observations which resulted immediately in the discovery. The record showed clearly that the patentees planned the experiments in progress when the discovery was made, directed the investigations day by day, conducted them in larger part personally, and interpreted the results.

This doctrine applies to either a draftsman or a cost accountant in constant and intimate association with development work which he completes. However, it does not apply to one who first solved a problem perplexing his shop and, in presenting a model made after hours at home, asked for a reward far above that given by the "suggestion system" of the plant, under which he refused to offer the idea.

Sometimes it is difficult to determine who should be named as inventor, no question being raised as to the employer's ownership of the invention. Clearly, if title vests solely under the employer-employee doctrine, the employer is the proper one to take the oath; but where an employee under contract to assign, in carrying out his employer's instructions, changed a vital element, a patent taken out in his name at his employer's suggestion was upheld.

In contests between an employer and employee, the duty of proving that an employer-employee relation exists is upon the employer. When the relation is proved and both claim the invention, the doubtful cases are decided in favor of the employer unless the employee can show with certainty that the invention was his conception.

The reason for this tendency was recently expressed in the following language: "The temptation of the employee to gain knowledge while working under the skilled guidance of another and then to seek to capitalize such knowledge by betraying his trust and seeking a patent for himself is always great and too frequently occurs."[5]

TITLE

The general rule of patent law is that in absence of a contract to assign an invention to the employer, the legal title to a patent for an invention made by an employee during his regular time of duty, with the employer's tools and materials, belongs to the employee. The right to exclude is inseparable from title. Legal ownership by the employee consequently carries with it the right to exclude or not to exclude, and therefore the right to give licenses to the business rivals of the employer so they may use in competition with him the invention. This is true notwithstanding the fact that the employer paid all the expenses of designing, testing, perfecting, and frequently the entire cost of taking out the patent, because by law the application *must* be made by the inventor, this being true even though at such time he may have parted with all rights under the patent that is to be granted.

Thus the mere fact that an inventor at the time of making his invention is in the employ of a person, a firm, or a corporation, does not transfer to the employer any title to or interest in that invention. The employee has a right, in the absence of a contract to the contrary, to turn his inventive genius in any line he wishes with the assurance that whatever invention results therefrom is his own personal property.

Such a contract to the contrary may arise by reason of a written, an implied, or an oral contract to assign the title. Reserving until later questions of interest in an invention which are short of ownership, contracts for title will be considered in reverse order, namely, oral, implied, and written.

ORAL CONTRACTS

The old rules regarding verbal contracts were rigid and the one-year provision of the statute of frauds was strictly applied. Today, however, an oral employment contract can be enforced to compel an inventor to assign his patent to his employer, no normal words of agreement being necessary. While the fact that an oral contract can be performed within one year is sometimes referred to, this is surplusage, as an oral agreement for the sale and assignment of the right to obtain a patent is not within the statute of frauds or R.S. 4898. Even under the older law an oral contract would be specifically enforced by a court of equity if sufficiently proved, certain, fair, and just in all its parts, as well as being a clearly concluded agreement in terms so plain that neither party could reasonably misunderstand them.

In one case where the officers of the employer corporation, in hiring an expert to design a somewhat undeveloped tire and to assign the invention, all understood that like inventions should pass to the employer, the reasonable failure of the employee so to understand the terms of the contract prevented the passing of title to a later invention on a somewhat different mold.

In a similar case, the title went to the employer because the inventor, under an oral employment agreement to develop magnetic separators in part of his time, had previously transferred to the employer without question two patents less valuable than the one in suit. The court stated that except for this proof of a meeting of the minds, the ownership of the patent could have been decided in favor of the inventor.

In all such cases where it is doubtful whether the minds of the parties have met, title does not pass, and where the minds probably have met at some time, the title passes or not in accordance with the construction of the contract placed upon it by both the employee and his employer as evidenced by their courses of conduct in relation to it prior to the later misunderstanding.

From this discussion it is quite evident how clear the right of the employer must be before he may secure all rights to inventions he surely must have *thought* would be his in view of his expenditures for wages, equipment, and materials.

IMPLIED CONTRACTS

An implied contract to assign may arise in several ways. The most common is when the inventor is employed to devise or perfect some definite device or to invent a method or means to accomplish a desired result. The general rule and the exception to it may best be cited in the exact words of the Supreme Court in Solomons vs. United States:[6]

> The government has no more power to appropriate a man's property invested in a patent than it has to take his property invested in real estate; nor does the mere fact that an inventor is, at the time of his invention, in the employ of the government transfer to it any title to or interest therein.
>
> An employe, performing all the duties assigned to him in his department of service, may exercise his inventive faculties in any direction he

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[2] Union vs. Van Deusen, 90 U. S. 530 (1875).

[3] Milwaukee vs. Sludge, 21 U. S. P. Q. 69 (1934).

[4] Minerals vs. Hyde, 242 U. S. 261 (1916).

[5] De Forest vs. Owens 9 U. S. P. Q. 387 (1931).

[6] 137 U. S. 342 (1890).

> chooses, with the assurance that whatever invention he may thus conceive and perfect is his individual property. There is no difference between the government and any other employer in this respect.
>
> But this general rule is subject to these limitations: If one is employed to devise or perfect an instrument, or a means for accomplishing a prescribed result, he cannot, after successfully accomplishing the work for which he was employed, plead title thereto as against his employer. That which he has been employed and paid to accomplish becomes, when accomplished, the property of his employer. Whatever rights as an individual he may have had in and to his inventive powers, and that which they are able to accomplish, he has sold in advance to his employer.
>
> So, also, when one is in the employ of another in a certain line of work, and devises an improved method or instrument for doing that work, and uses the property of his employer and the services of other employes to develop and put in practicable form his invention, and explicitly assents to the use by his employer of such invention, a jury, or a court, trying the facts, is warranted in finding that he has so far recognized the obligations of service flowing from his employment and the benefits resulting from his use of the property, and the assistance of the coemployes, of his employer, as to have given to such employer an irrevocable license to use such invention.

Until sharply called to account by the Supreme Court in a later case[7] the lower courts did not follow any too well the pronouncement regarding title as expressed in the foregoing citation, doubtless because in the Solomons case the title to the patent was not in issue and the decision was merely that the government had a right to use the invention. The comment regarding title was therefore considered as "obiter dicta," that is, an opinion expressed by the court on a point not involved in the case and consequently not entitled to the force of an adjudication. Because of the importance of the later case it will be given in some detail.

Peck, a patent lawyer and engineer, was employed by the Hess-Pontiac Axle Company under contract "to devote his time to the development of a process and machinery for the production of the front spring now used on the product of the Ford Motor Company." He received a salary of $300 per month for the part-time work, plus a bonus of $100 per month if the work were completed within a given time, plus $10 for each percentage of reduction from direct labor. He did develop the machinery for making the springs and patented it. The Hess company made a number of machines and was then absorbed with other axle companies by Standard Parts Company which continued to make such machines for use by it, selling the product of the machines, but never the machines. On suit by Peck the court of appeals held that Peck owned the patents but the Hess Company had a shop right which, however, was not transferred by the ordinary purchase and sale of a business and covered only such of the ten machines as were made by Hess rather than by the Standard Parts Company.

The Supreme Court reversed,[7] held that the property in the inventions belonged to the employer, ordered Peck to assign the patents to Standard, and stated:

> By the contract Peck engaged to "devote his time to the development of a process and machinery," and was to receive therefore a stated compensation. Whose property was the "process and machinery" to be when developed? The answer would seem to be inevitable and resistless—of him who engaged the services and paid for them, they being his inducement and compensation, they being not for temporary use but perpetual use, a provision for a business, a facility in it and an asset of it, therefore, contributing to it, whether retained or sold; the vendee (in this case the Standard Company) paying for it and getting the rights the vendor had (in this case, the Axle Company).
>
> Other meaning to the contract would confuse the relation of the parties to it—take from the Axle Company the inducement the company had to make it—take from the company the advantage of its exclusive use, and subject the company to the rivalry of competitors. And yet, such, we think, is the contention of Peck. He seems somewhat absorbing in his assertion of rights. He yields to the Axle Company a shop right only, free from the payment of royalty, but personal and temporary—not one that could be assigned or transferred. Peck, therefore, virtually asserts, though stimulated to services by the Hess Company and paid for them—doing nothing more than he was engaged to do and paid for doing—that the product of the services was so entirely his property that he might give as great a right to any member of the mechanical world as to the one who engaged him and paid him—a right to be used in competition with the one who engaged him and paid him.

In the Peck case, while the contract to assign was an implied one, there was a written contract of employment specifically reciting the article to be invented. In absence of a written agreement of some kind it is almost invariably held that employment of a skilled inventor, designing engineer, expert research man, or general superintendent, to devote his entire time and energy to the development and perfection of the articles which the factory produces, is not in itself sufficient to transfer title to the employer.

In one exceptional case the president of a corporation was ordered to assign his patent to the corporation, there being an arguable point whether or not in that circuit a president is an employee. The court held that if the patent were for a detail it would belong to the inventor, but stated: "Here the patent involved the very life of the corporation. It was developed by the whole corporate force, as something absolutely necessary, under the supervision of the president who was straining every nerve to make good. It entered vitally into the very business life of the company."[8]

It should be noted that in this case there was doubt that a shop right would pass; the practical owner of the corporation had implicit trust in the president; had given him sole charge of the business; and had loaned him money to make him the second largest stockholder.

That case is unique, for in the only other contest wherein a president was required to assign to his corporation in absence of any understanding, he had been the sole stockholder of the corporation which had been sold to a second corporation of the same name and he had misappropriated more than a million dollars from the second company, part of which he used to patent his inventions in the names of third parties.

In a third case, involving title to a patent issued to a chief engineer who had full charge of all mechanical departments with the duties of improving and designing new cars, transfer of ownership to the employer was refused by a divided court of appeals in spite of the showing that the inventor had assigned many less valuable patents to the company, as a result of which his salary had successively been increased. The dissenting circuit judge accurately observed that the engineer was paid to invent, was merely doing what he was hired to do, and the fruits of his inventive labor belong as much to the employer as would the fruits of his mechanical skill. This inventor must have recognized that his inventions belonged to the employer as shown by his earlier repeated assignments without question.

In the many cases where an inventor-employee has kept title to his invention although hired to design, develop, and perfect the output of the factory, several involved one who seemed to be well within the exception to the general rule. For example, Hewitt[9] was hired to devote his time and services to designing, improving, and perfecting plows. Dalzell,[10] in asking for a raise (and getting it), promised important improvements in tools for making watches. Patch[11] not only was employed to develop the Speed Queen washing machine but was given staged promotions from $2700 to $7000 as a result of his inventive genius and was relieved of his routine duties as production superintendent to give him more time to design improvements.

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[7] Standard vs. Peck, 264 U. S. 52 (1923).

[8] Dowse vs. Federal, 254 Federal Reporter 308 (1918).

[9] Hapgood vs. Hewitt, 119 U. S. 226 (1882).

[10] Dueber vs. Dalzell, 149 U. S. 315 (1893).

[11] Barlow vs. Patch, 42 U. S. P. Q. 211 (1939).

It is only fair to state that of these three cases, the first[8] was decided almost sixty years ago. The court believed neither party in the second case,[10] acidly observing "impeaching Dalzell does not prove that Dueber's testimony can be relied on." In the third case,[11] which was settled by the Wisconsin Supreme Court, the decision was predicated upon the thought that the evolution which took place in the character of the inventor's employment did not go so far as to bind him to transfer to his employers the title to a valuable invention.

Under similar circumstances the federal court of appeals for the circuit which includes Wisconsin ordered the inventor of a magnetic separator to assign to the employer. The difference between the two cases was that the inventor in the Wisconsin case had just made his first invention in washing machines and at once refused to assign it, while in the federal case the minds of the two parties had undoubtedly met at some earlier date, as shown by the prior transfer without question of two less valuable patents on the magnetic separator.

From this it will be seen that the course of conduct of the parties will govern in implied contract cases to even a greater extent than in cases involving an oral agreement. While perjury is really rare in these proceedings, highly colored testimony and convenient memories were all too common in the days before the present open court procedure in which the federal judge who sees and hears the witnesses can separate with uncanny skill the wheat from the tares and the chaff.

GOVERNMENT AS EMPLOYER

With the exception of those employed in the Patent Office (R.S. 480), any servant of the United States may apply for and receive a patent. It is well-settled law, for example, that any man of the armed service from lowest rank to four-star grade may patent military or naval equipment and collect royalties for the use of that equipment, provided only that he has not been specially ordered to make experiments with a view to suggesting improvements.

The most important case in this category was decided by our highest court a few years ago in a suit by the United States to obtain title to a group of patents so that the public could use the inventions. It involved two employees of the radio section in the Bureau of Standards who had made inventions in line with work which they normally performed but to which they had not been specifically assigned. Certain other projects were definitely assigned to the two inventors and the rule of the Bureau was such that these research engineers had much freedom and could work on any feature in the radio field that offered promise of fairly ready solution. All work was done on government time and with government materials. When the inventions were partially made they were shown to the section chief and with his express approval considerable time was then devoted to perfecting them. When the chief learned that the employees had applied for patents he demanded that they assign their patents to the government and they refused. They again refused when a representative of the Department of Justice made the same demand.

The Supreme Court divided sharply,[12] the majority holding that the inventors could be deprived of their rights under the patents only by proof that the inventors were employed to devise the inventions. They urged that although the inventors were employed as research engineers to advance the radio art, there is nothing in the word "research" which connotes invention and therefore the inventors were not employed to invent the particular combinations which they patented. Rather the case came under the rule that if the employment be general, even though it covers the field of labor and effort in which the patents are concerned, the contract of employment is not so broadly to be construed as to require an assignment of the patent in absence of an express agreement to that effect.

This case presented great difficulty, for to transfer title, or to cancel the patents as suggested by Chief Justice Hughes, would be to extinguish all rights which the patent owner, in good faith, had purchased, assuming, as held by the majority, that the employment did not contemplate the exercise of inventive faculties as distinguished from a high degree of scientific skill. No decided case had gone as far as the government requested in this suit.

On the other hand, however, these men were employed in a bureau maintained for the public interest and in a section whose duty it was to advance the radio art by invention just as much as by discoveries falling but slightly short of being dignified by that appellation. It may be true that these inventions all related to radio reception in homes whereas the inventors' individual group was assigned to airplane radio, yet it would be idle to suggest that the work done both in originating and in perfecting these inventions was not within the scope of their duties in view of the freedom given these men to work for the general good under the established practice of the radio section. A patent gives the right to exclude, and that right includes the power to suppress; this is the very antithesis of furthering the interests of the public by advancing the radio art, and this latter, as the patentees well knew, was the policy governing the research they were paid to promote.

WRITTEN CONTRACTS

The law concerning written contracts in general is extensive, and as it includes patent contracts, the latter will therefore not be treated here except as to a few points. The contract may provide for ownership in either employer or employee with or without actual remuneration for the transfer of title or the right to manufacture. For example, it may provide that the employee shall keep title and receive half the profits from all foreign business and the employer shall have a free license in the United States.

A contract to "make and execute any and all assignments in writing which may be deemed by the employer proper or necessary to transfer and vest in the employer the entire right, title, and interest in all inventions and discoveries made by the employed during the term of his employment was held valid, although it provided that no breach of the contract by the employer should relieve the employee of his obligations.

While it is best to limit the time after termination of employment, it is legal to contract for present and future improvement and developments in some one narrow field. However, in the decision usually cited as authority for this, the point was immaterial as the invention involved was made during the term of employment, and was based on the decision warning against "a mortgage on a man's brains to bind all its future products." Equity courts may limit the field of invention to make the contract valid, particularly where the inventor has a regular business aside from that line.

The consideration for the contract is usually the employment itself, or, if the employee has been employed for some time before making the contract, the continuation of employment is sufficient. The employer is under no obligation to continue the employment and could make the requirement to assign a condition of retention. The Wagner labor act doubtless may modify the latter statement.

Equity courts may interpret the terms of a contract which is not clear. The reason is that the relief may be granted or not at the discretion of the judge so the latter may require either party to do whatever is necessary to insure fair dealing as a prerequisite to the answering of the granting of the prayer for relief, following the maxim, "He who seeks equity must do equity."

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[12] U. S. vs. Dubilier, 289 U. S. 178 (1933).

SHOP RIGHT

To understand fully the principle of shop right we must go to its origin. It is in that doctrine of equity known as estoppel, requiring one to assert his rights when he should, under penalty of being barred from proving these rights at a later time. The schoolbook example is that of the owner of a horse who stands idly by while another sells this horse to a buyer. If the purchaser acted in good faith in buying the horse and had no reason to believe that the seller was not the owner, the true owner will not later be permitted to testify that the horse is his.

Until 1839 it was incumbent upon an inventor to apply for patent prior to any public use of his invention whether by his employer or by any other individual having his permission. Hence few questions of shop right arose until the old law was amended to allow a period of public use for testing the invention before applying for the patent. An interesting early case under this changed law concerned the valuable process of casting iron rollers or cylinders by a centrifugal action in the mold so the dross would be thrown toward the center instead of the surface as with all previous methods. This desirable result was obtained by changing the direction of the pipe leading from the furnace to the mold—instead of being perpendicular to the mold axis it was made tangent to the cylindrical surface of the mold.

The inventor was employed by a foundry at weekly wages. After several unsuccessful attempts, he devised this method of casting in the course of his employment and his wages were increased because of the useful result. He suggested that the foundry buy his rights, an offer which was declined. A year later he left this employ, as a result of a misunderstanding concerning a different matter, and sold his patent to a rival foundry, which entered suit.

The Supreme Court[13] held that the facts "amounted to a consent and allowance of such use and show such a consideration as would support an express license or grant, or would call for the presumption of one to meet the justice of the case, by exempting the employer from liability." Hence the original foundry had a right to the continued use of the invention which it was using during the time the inventor was employed by it.

A shop right may arise whenever the inventor or other owner of an unpatented invention allows it to be used by another, particularly where he induces or assists in such use without demand for compensation, or other notice of restriction of the right to continue. The user may then be considered to be the possessor of an irrevocable but nonassignable equitable license to use that invention. The theory is that since the user has assumed expense and has put himself in a position where he would be injured if compelled to relinquish further use of the invention, it would be unfair to permit the owner to profit by failure to object at the appropriate time.

Such a shop right is a personal license, and while it will pass to the employer's successor which takes over the complete business as, for example, when a firm incorporates, or a corporation is merged with another and gives up its corporate existence, it does not pass to a corporation organized to succeed a bankrupt business sold by the receiver unless the inventor happens to continue in the employment through the time of transition and with the same duties. In this latter case it is probably inaccurate to say that the shop right followed the employment. Rather it is a case of the creation of a new shop right by the acts of the parties.

It frequently happens that the inventor thinks of an invention in his own time, makes a rough sketch or model, and brings this to his employer for approval. If nothing is said to the contrary, the completion of the invention in the regular course of the business, with or without the inventor's aid, definitely gives a shop right to the employer.

Whether or not a shop right exists where the inventor tries to perfect the invention and is unable to do so until after he leaves the employ, depends largely upon the facts. In one recent case the court held the employing corporation should be permitted to continue to make available the investment and experimentation which was made under the inventor's direction in the joint enterprise of himself and the others in the corporation. Earlier cases would seem to indicate that if the invention were not completed at the time the inventor left his employment the employer would not have a shop right in the perfected article or machine.

There are more than a dozen cases in which it has been held the employer had no shop right but all presented facts showing that the inventor differed from the usual course of conduct. For example, there would be no shop right if the inventor were not an ordinary employee, but was, for instance, a salesman on commission, particularly if he represented other firms in his selling. In such a case, especially if he profited largely by his sales commissions, equity courts go quite far in protecting him against an employer who had not played fair with him.

Other cases of this kind concern inventors who claim to have made the invention after leaving the employ. This, of course, resolves itself into a question of proof. In the cases where it has been held that the employer has no shop right, there has been lack of definite testimony that tangible work was done until after resignation. When the employer waits a long time to assert a shop right, the courts are likely to find he is entitled to no license of this kind.

Exceptions to the general rule are found when an ordinary employee makes an invention in rough form in a somewhat different branch of work and, when submitting it to the employer, makes a clear and definite statement that he expects pay for the *use* of it. This avoids the foundation for creation of a shop right, that is, there can be no estoppel. Reduction to practice by the employer under such circumstances will not create a shop right but neither would the employee escape the shop right if the discussion as to payment had to do solely with the sale of the patent or the invention without mentioning the shop right, or the right to use.

CONCLUSION

Throughout all the decisions on the question of the employee's share in his own invention, there is a surprising lack of appreciation by the courts of the value to the employer of the right of exclusion. So frequently we read in legal opinions that the employer should be satisfied with a shop right for that is sufficient to enable him to keep up with the growing art. It is forgotten that the employer is striving for something the others can be prohibited from using; something he may feature in his advertising. It is not enough that his goods be excellent; they must have sales appeal. The factory cost of an article is usually limited to one third the retail price. An equal amount goes to selling, where a key word to success is "exclusive," a word foreign to shop right and existing only in the ownership of a patent.

It is perfectly possible to combine this right of exclusion by the employer with a right to suitable recompense for the employee. This may best be done by the parties at a time when their relations are friendly and their interests mutual. They should provide in writing for such division of the rewards of inventions yet unborn as may then seem fairest to both. The agreement, signed in duplicate, should be full and complete, preferably in simple language.

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[13] McClurg vs. Kingsland, 42 U. S. 202 (1843).

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

EVENTS in Western Europe since May 10 have produced widespread and unpredictable repercussions in the rest of the world. Neutrality of almost any sort has become a pretense on one hand and an invitation to invasion on the other. The halting methods and divided counsels of a nation whose government is based on the consent of the governed have presented an inadequate defense against those of nations subject to the dictation of a single leader. The fourth dimension—time—has at last become a grim reality instead of an academic concept. The war of nerves has developed into as good an imitation of the total war of yesterday's prophesies as anyone can wish.

In the space of a few weeks public opinion in this country has swung sharply away from the peace-at-any-price and appeasement doctrines to the desperate belief that security in this continent can be assured only by a strong national defense program. Engineers have once more been forced to acknowledge that the prostitution to inhuman and aggressive techniques of the invention and developments designed for peaceful pursuits has made possible the spectacular advances of blitzkrieg warfare in the Netherlands, France, and Flanders. Debate rages over the relative merits of aerial and naval warfare. Dive bombing, machine-gunning from low-flying airplanes, bombing from the air of locations inaccessible except by way of the sky are cogent arguments in favor of the superiority of the air force. Yet the evacuation of the trapped allied armies in Flanders is a telling point in favor of sea power.

Awakening suddenly to the inadequacy of its defenses in all departments of the military forces, the nation has turned its energies to adding to its strength with the hope that time still remains to accomplish the obvious minimum objectives. The President has asked for enormous sums of money to be spent for the national defense. Taxes will be increased. He has talked of an air armanda of 50,000 planes and Mr. Ford has made predictions of mass-production accomplishments that have staggered some and set others to scoffing. A National Defense Advisory Committee has been named on which three representatives, if no others, have been approved by engineers and industrialists—Knudsen, Stettinius, and Ralph Budd. Two A.S.M.E. members, W. L. Batt, president SKF Industries, Inc., and Gano Dunn, president J. G. White Engineering Corporation, have been appointed to the staff of the committee. Authority of the President to call the National Guard, should emergency demand it after the adjournment of the Congress, is under debate. America is thoroughly aroused and intent on the ways and means of defending itself and its liberties. Talk of universal military service is being heard with approbation.

In hundreds of specialized branches the lessons of the war in Europe and the mistakes that have been made are being studied. It is in this sector that the most useful results will be found to guide America in the coming months. To the astonishment of the entire world, Nazi energy and singleness of purpose have overcome the handicaps of inadequate natural resources and what appeared to be an almost bankrupt economy. But Germany has merely demonstrated age-old truths about human conduct and accomplishment. She has mobilized her entire citizenry, in a manner, to be sure, that can be adopted in democratic countries only as a last and desperate resort. From scientist and engineer to the worker himself strict attention to the national will and purpose has demonstrated the superiority over natural resources and accumulated wealth that lies in hard work. She has demonstrated the effectiveness of the crusading spirit when it grips an entire people and personal, selfish ends are subordinated to the national objective. She did not have to temporize with the futile dreams of bootstrap lifting and short cuts to ease and leisure that delayed the defense program of France under the *front populaire*. Regardless of how history may judge the Nazi cause and its methods, it will, no doubt, testify to the truth of that ancient and hard saying: "In the sweat of thy brow shalt thou eat bread."

The lessons for America, and particularly for its engineers and industrial population, do not lead to a justification of piracy, pillage, and brigandage as a means of acquiring a higher standard of living for its people. They teach, rather, that wise leadership, an industrious citizenry united in a common objective, well equipped with intellectual and material resources, can accomplish almost anything it sets out to do. The present problem is one of purpose and program, of national unity, of responsible and wise leadership, of calm realistic decisions, of the preservation of the values of a way of life at the temporary expense of some of its material fruits. On no class does a greater responsibility lie than on engineers whose fertile minds and productive arts can organize and develop for the common welfare the resources of a richly endowed continent. Once before within the memory of most engineers the profession and those allied with it came to the rescue of the type of civilization they preferred to have. For some, disillusionment and cynicism were overpowering factors that led to a disintegration of national ideals. The effect of this state of mind on the generations reared since the war has been unsettling. But the indications are that an awakening is taking place. The future will demonstrate whether that awakening has brought new vigor and whether it has come in time.

The progress of science, which it is always more gratifying to report than the progress of destruction, continues to involve uranium and the atom smashers. The scientists themselves are interested in techniques and acquisition of knowledge, the zeal that drives the research worker, but laymen and engineers are continually asking, What does it mean and what can you do with it? The release of power in large and controllable quantities and under commercial conditions that would make "atomic energy" a direct competitor of forms now in practical use excites the interest of mechanical engineers who may some day be called upon to construct and operate power plants of this new type. The mechanism of the nuclear fission process by which energy is released from the uranium atom is described by Karl K. Darrow in the *Bell System Technical Journal* for April, 1940.

For the benefit of those who like their science news served to them in popular layman's language, John J. O'Neill, science editor of the New York *Herald-Tribune*, has presented an article "Enter Atomic Power," in the June, 1940, issue of *Harpers Magazine*. Mr. O'Neill explains what it is all about and, like a good newspaperman, gets right down to word pictures of what practical use this potential source of power would find in the home, the automobile, the ship, railcar, and airplane, in agriculture, and in manufacturing. Moreover, he asks what the economic effects are likely to be on such industries as those producing fuels, coal, and petroleum, on the railroads, the automobile manufacturers, and the public utilities. But he does not leave us expecting the new power source next week, for he shows that U 235 is scarce and difficult to extract from the ores of ordinary uranium, and, after all, the cost may be prohibitive. However, the scientists are at work on the problem and the engineers will follow in their train just as soon as conditions warrant it. One remembers that aluminum was once a semi-precious metal and that "heavy water," one of the rarest substances a few years ago, can today be purchased in heavy concentrations and in large quantities from commercial producers. It will bear watching, this progress being made in the release of atomic energy.

Electrolytic Polishing of Steel

STEEL

DEVELOPED particularly for the finishing of fabricated articles of steel to which mechanical polishing can be applied only with difficulty, if at all, a new electrochemical polishing process utilizes anodic treatment, which is the reverse of electroplating. Electrolytic polishing as such is not new. A French patent was issued in 1931 for a method of anodically treating metals in certain electrolytes with an anhydrous solution of glacial acetic acid and perchloric acid as the preferred medium. But, as described in *Steel*, April 22, 1940, by A. L. Feild and I. C. Clingan, use of this solution involves definite hazards, because of its corrosive properties, toxic fumes, and danger of explosion when brought into contact with organic substances such as oil or grease.

Considerable work has been done in this country since then. Some half dozen processes are now in various stages of development. The authors describe one which is now being introduced on a commercial basis in various parts of the United States. In this process, the electrolytic polishing comprises an anodic treatment in an electrolyte composed of citric acid (30 to 70 per cent by weight), sulphuric acid (10 to 30 per cent), and the remainder water. Sum of both weights is about 75 per cent. Since neither citric nor sulphuric acid is volatile, there is no loss of these ingredients by evaporation. However, a small loss takes place because of the small amount which adheres to articles upon removal from the tank. The life of the electrolyte has not yet been determined but there are solutions which have had more than a year of continuous service and are still in service unimpaired. Under operating conditions the electrolyte has a slight sweetish smell but no noxious fumes. Hoods and ducts are unnecessary but are advisable in the case of large installations if the roof is unusually low due to the fact that hydrogen is evolved from the cathode as in all acid baths.

In one installation the bath is operated between 180 and 190 F, with heat supplied when necessary by electric immersion heaters. Usually, additional heat is not needed since operation of the process itself maintains bath temperature. Direct current is provided by a 7500-amp, 12-v motor-generator set operated between 6 and 9 v, depending upon conditions of the solution, with 7.5 as normal operating voltage. Current density ranges from 0.5 to 1.5 amp per sq in. of surface metal, according to size and surface condition of article being polished. Articles to be polished are placed in work racks which are coated with a chromium-rubber compound except at contacts which are made of a copper-silicon alloy. In the process, the articles constitute the anodes and a small amount of their surface, usually 0.001 in., is removed. The metal removed forms metallic salts which fall to the bottom of the lead-lined tank and are subsequently removed as sludge.

Work being treated is carried around a tank (33 × 5 × 3 ft deep) by a moving carrier with 24 hangers. Articles are placed on and taken off the carrier at one point by a single operator. However, in other installations, the process is conducted in ordinary lead-lined tanks of the chromium or nickel-plating type. After the work has passed through the electrolyte, articles are dipped in a reclaim rinse, which is used as water addition to the electrolyte. Next follows an alkali rinse which serves as a neutralizer. Articles then receive a final hot-water rinse.

Time required in the electrolyte depends upon surface condition, size, and shape of the article. The time required for such articles as 18-8 stainless-steel meat-saver trays is about 4 minutes, whereas in the case of 17 per cent chromium refrigerator shelves the time is about $7^1/_2$ minutes. However, in treating broad surfaces it is difficult to obtain as flat a mirror finish as is possible by mechanical methods due to problems of current distribution and nature of the original sheet finish. This characteristic is hardly noticeable when sheet or strip is fabricated into small articles with curved surfaces. High spots and sharp projections are removed as the current tends to concentrate at these points, resulting in a greater metal loss and a smoother finish.

The process, despite its limitations, has been employed successfully in polishing a wide range of fabricated products, such as sink strainers, bezels, drainer trays, fuse holders, test-tube racks, tablespoons, and the like. Some work also has been done on electrolytic polishing of stainless-steel forgings and castings. The treatment does not provide a smooth finish but it imparts to the surface a high intrinsic luster.

Increasing Camera-Lens Speed

JOURNAL OF THE OPTICAL SOCIETY OF AMERICA

THE effective speed of a camera lens can be almost doubled by treating it with low reflecting films, states C. H. Cartwright in an article appearing in the March, 1940, issue of the *Journal of the Optical Society of America*. This phenomenon was observed as early as 1892 by Dennis Taylor when he noticed that tarnishing of camera lenses led to an increase of their effective speed. The tarnished surfaces of the glass elements of high refractive index diminished the reflection of light from the air-glass surfaces and thereby increased the transmission of the whole camera lens. Various methods were devised for artificially tarnishing glass but apparently the results were not sufficiently effective to justify their adoption by the manufacturers of camera lenses.

It is now evident that the tarnish is actually a film of a transparent material having a lower index of refraction than that of the glass. To be most effective, such a film must fulfill specific requirements. A homogeneous film that reduces reflection to zero for one particular wave length of light must satisfy two conditions, namely, the index of refraction must be equal to the square root of that of the glass, and it must have an optical thickness of one fourth of the wave length of the incident light. These two conditions can be satisfied rather well by evaporated films of the metallic fluorides deposited on glass in vacuum.

An *f*2 photographic lens having five separated elements was treated with evaporated calcium fluorite to decrease the reflection from all ten air-glass surfaces. Photographs were taken with the lens under carefully controlled conditions before and after it was treated. The effective speed of the lens was found to be almost doubled by the treatment. A slight increase in contrast resulted in photographs taken under normal lighting conditions and a large increase in contrast resulted in those taken under adverse lighting conditions. An increase in detail was observed, because of the absence of flare, and the ghost images usually observed under adverse lighting conditions were eliminated.

Wire Tension Meter Uses Sound

MECHANICAL TOPICS

THE actual load on a wire rope or solid wire up to $^3/_8$ in. in diameter can now be measured with a simple and inexpensive tension meter, according to a note in *Mechanical Topics*, Vol. 1, No. 4. The meter measures tension from the tone which a wire sounds when plucked. It is an application of a simple, basic principle that there is a definite relationship between the tension and tone pitch of a loaded wire. The greater the tension, the higher the pitch.

In making a test, the wire to be checked is fastened to the meter in such a way that a definite length rests on two bridges fixed to the hollow metal sounding box. Alongside of the wire being tested is a standard toning wire whose frequency can be varied by placing a finger on it at any part of its lower length. After the tone of the standard wire matches that of the wire being tested, the figure on a calibrated scale at the point where the finger finally rests is read and used as an index to a set of tables which gives the actual load in pounds together with safety factors for any type of wire.

Occupational Health Hazards

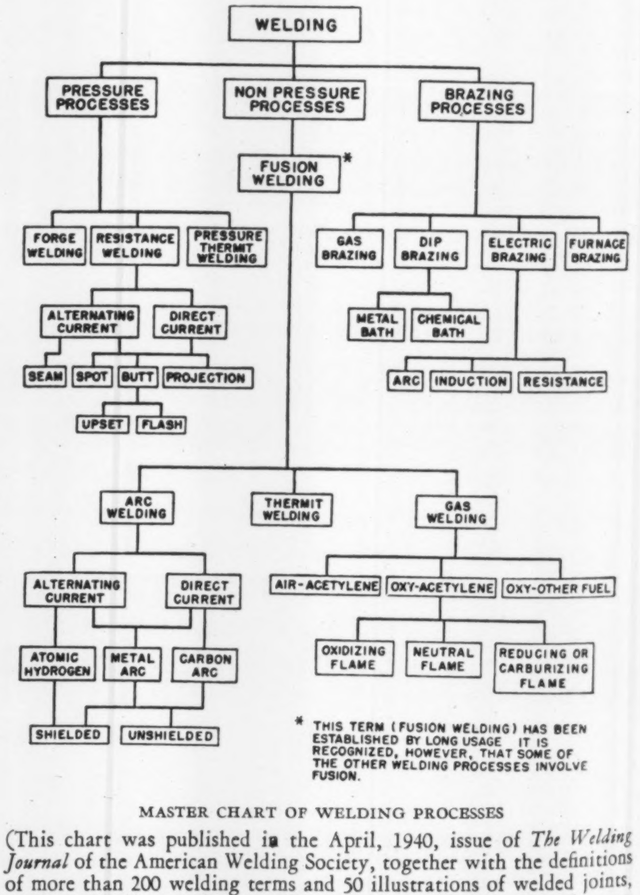
DEPARTMENT OF LABOR, STATE OF NEW YORK

GROWTH of modern industry has brought with it an increasing number and variety of hitherto unknown health hazards, such as dusts, gases, and fumes. In a five-year study, now in its fourth year, being conducted by the Department of Labor, State of New York, under an annual appropriation of $50,000 from the Legislature, the toxic properties of commonly used substances, such as benzol, bakelite, catalin, carbon disulphide, chlorinated hydrocarbons, hydrogen, insecticides, methyl cellusolve, mineral oils, aniline dyes, acetone, formaldehyde, nitrobenzene, methanol, and others, have been brought to light. Some of these substances attack the nervous system, others destroy blood, a few cause serious or even fatal liver diseases, and several cause cancer of the skin or bladder. Still another group of substances cause dermatitis, asthma, or other allergic diseases.

It is brought out in the 1939 progress report of the Department of Labor to the Legislature, that "practically all of these substances can be used with perfect safety, provided proper ventilating safeguards are maintained and unnecessary air contamination avoided." The experience which has accumulated in the Division of Industrial Hygiene of the Department in the handling of exhaust systems and the development of proper tests has come to be recognized as of great assistance to employers and plant managers. This information is available to every one through the Division's distribution of a series of "Recommended Practice Sheets," which contain the results of current field studies as they are developed by the engineering staff. These sheets provide technical information with reference to the design of exhaust systems for special industrial processes and other details with reference to exhaust systems for specific industrial health hazards.

One of the first problems tackled under the study was that of silicosis. Though a method of curing this disease has not yet been found, the Department has developed methods of preventing it through dust-control measures which, in order to be effective, are being continuously and persistently applied. Four new industrial codes have been developed to curb silicosis hazards in rock drilling, foundries, stone cutting, and stone crushing. The practicality of the rock-drilling code is facing a severe, but successful, test in the case of the Delaware Aqueduct, an 85-mile rock tunnel under construction by the City of New York to increase its water supply. Most of the drilling is being done in hazardous silica rock. Approximately 360 drills are in operation at once, more than a mile of tunnel is driven each week, and nearly 10,000 tons of rock are removed each day. The silicosis hazard to the 6000 men on the job is controlled by carefully tested and maintained ventilating systems and wet drills.

In 1938, 175 fur-felt hatmakers in a plant in a small Hudson River community were found to be suffering from mercury poisoning. Basic engineering studies of every process in the plant resulted in recommendations for specific ventilating systems and the separation of the more hazardous functions from the main workroom. Grouped around the Engineering Socie-


WELDING
PRESSURE PROCESSES
NON PRESSURE PROCESSES
BRAZING PROCESSES
FUSION WELDING*
FORGE WELDING
RESISTANCE WELDING
PRESSURE THERMIT WELDING
ALTERNATING CURRENT
DIRECT CURRENT
SEAM
SPOT
BUTT
PROJECTION
UPSET
FLASH
GAS BRAZING
DIP BRAZING
ELECTRIC BRAZING
FURNACE BRAZING
METAL BATH
CHEMICAL BATH
ARC
INDUCTION
RESISTANCE
ARC WELDING
THERMIT WELDING
GAS WELDING
ALTERNATING CURRENT
DIRECT CURRENT
ATOMIC HYDROGEN
METAL ARC
CARBON ARC
SHIELDED
UNSHIELDED
AIR-ACETYLENE
OXY-ACETYLENE
OXY-OTHER FUEL
OXIDIZING FLAME
NEUTRAL FLAME
REDUCING OR CARBURIZING FLAME
* THIS TERM (FUSION WELDING) HAS BEEN ESTABLISHED BY LONG USAGE IT IS RECOGNIZED, HOWEVER, THAT SOME OF THE OTHER WELDING PROCESSES INVOLVE FUSION.

MASTER CHART OF WELDING PROCESSES

(This chart was published in the April, 1940, issue of *The Welding Journal* of the American Welding Society, together with the definitions of more than 200 welding terms and 50 illustrations of welded joints, weld terminology, and type of flames. Prepared by the Committee on Definitions and Chart, the material was approved as "tentative" by the executive committee of the Society on Jan. 18, 1940.)

ties Building in New York City are more than 60 women's hat factories. When workers in these factories started to be overcome by carbon-monoxide poisoning on Monday mornings, engineers found the cause of this common occurrence to be due to the fact that since it took a little time to get the building heated after the week end, the gas burners of hatmaking equipment were lighted, with the windows closed, to heat the plant. The carbon monoxide given off was too much for the workers. This hazard was brought under control by the engineers through education and the development of an efficient gas burner which saved enough gas in one month to pay for the cost of installation.

Industrial Power Correlation

METROPOLITAN SECTIONS, A.S.M.E. AND A.I.E.E.

EFFICIENT utilization of steam and electric power in industrial plants depends upon many factors which must be carefully studied and worked out for each case, states G. G. Hollins, member A.S.M.E., and chief engineer, J. G. White Engineering Corp., in a paper presented at a joint meeting of the Metropolitan Sections of the A.S.M.E. and the A.I.E.E. in New York City, March 21, 1940, and published in full in the April, 1940, issue of *Combustion*.

The economical supply of steam and electric power requires a study of the following methods of steam and power production: (1) Generation of steam and purchase of power; (2) generation of steam for process and power generation with steam condensed or wasted or the use of internal-combustion engines for power; (3) generation of steam at sufficient pressure to generate power and to use all the extracted and exhaust steam for process; and (4) combinations of these three methods.

In regard to the first, if use of steam is small or too much out of phase with the electric power requirements and the cost of purchased power is low, it may be more economical to have a low-pressure steam plant sufficient for the process steam or heating requirements and to purchase the electric power. If, on the other hand, purchased power is expensive and the fuel cost low but still the steam use is not suitable for making power with an extracting or noncondensing turbine, the second method may be advantageous, by making the power with an engine of the uniflow or four-valve type, a straight condensing turbine, or an internal-combustion engine.

The third method is the ideal heat balance of power generation for an industrial plant and is obtained when all the power required can be made by the steam passed through a turbine or turbines before going to the process, and the simplest arrangement is when the turbine exhausts at the pressure required for process. When two process steam pressures are required, the automatic extraction turbine is useful as it will supply the process steam requirements at the respective pressures within its load limitation.

The automatic extraction feature increases the cost of the machine appreciably in the smaller sizes and also increases the straight-through steam rate. For two regulated extracted steam pressures the double-automatic extraction turbine is used. This means another item of extra cost and further reduction in the efficiency of the turbine. When there are engines, steam-driven pumps, or air compressors in the plants producing an excess of exhaust steam, it may be advisable to use a mixed-pressure turbine into which this exhaust steam is introduced and expanded to a lower pressure to generate power. The mixed-pressure feature may be applied to an automatic extraction turbine, either to introduce the steam through the extraction opening or through another opening.

It is frequently not possible to have an ideal heat balance, or perhaps it would be better to say that the ideal heat balance may be approached but not frequently obtained. If obtained, it is often not maintained through the faster growth of the electric power load over that of the steam load.

The subject of topping turbines has a popular appeal and often owners of industrial plants expect that a topping turbine will do much more to solve their power-generation problems than is warranted by the facts. If an industrial plant is already using power-generating equipment, taking steam at about 400 lb, conditions are generally not favorable for superimposing a turbine generator exhausting at this pressure unless the power requirements are sufficiently large. This is because the initial steam conditions for a superimposed turbine would have to be about 1200 lb, 900 F, and 5000 kw, which is the smallest topping turbogenerator for such steam conditions that is commercially available at present. The quantity of steam exhausted from this size of machine at full load would be sufficient for about 7000 kw turbine capacity, operating between 400 lb and 20 lb, and about twice as much capacity operating between 400 lb and 2 in. absolute pressure. Pure feedwater is essential for high-pressure boilers and a plant using steam for process usually has a high percentage of make-up, too large for economical evaporation. This makes the water purification an important item and one that requires close attention.

In regard to auxiliary drives, steam and electric drives each have their advantages and disadvantages. Steam drives have an advantage in ease of speed control but have a higher steam rate than the main generating unit and the economical use of the exhaust steam is often a problem. Mechanical-drive turbines frequently require a speed-reducing gear and this adds to the cost of the unit and is another piece of equipment to be maintained. For a drive requiring a small amount of power it is usually cheaper and simpler to install an electric motor.

Electric Steam Boilers

AGRICULTURAL ENGINEERING

MANY farmers in California are using electric steam boilers to produce steam for sterilizing dairy utensils. These boilers are classed under two general types, the accumulator and the instantaneous. According to an article by J. R. Tavernetti and K. F. McIntire, appearing in the April, 1940, issue of *Agricultural Engineering*, accumulator boilers consist of relatively large, heavily insulated pressure tanks (30 to 75 gal) equipped with low-wattage heating elements (1500 to 3000 watts). Their name is derived from the fact that they depend on the accumulation of enough heat between sterilizations to generate practically all the steam needed for the sterilizing operations. They have the advantages of relatively high load factor, complete automatic operation, steam always available, large quantities of steam under pressure, ease of installation because special wiring is not necessary, low connected load sometimes resulting in lower electric rates. They have the disadvantages of higher initial cost and of producing only a small quantity of steam when the pressure has been reduced to zero.

Instantaneous boilers consist of relatively small tanks (7 to 13 gal), either lightly insulated or uninsulated, with high-wattage (5 kw to 15 kw) heating elements. Their name is derived from the fact that they depend on their instantaneous heating capacity to supply most of the steam for the sterilizing operations. They have the advantages of being able to supply a given rate of steam flow for an unlimited time as well as supplying a small amount of steam under pressure, of lower initial cost, and of lower energy consumption when sterilizing is done only once a day. They have the disadvantages of low electric load factor, of manual or semimanual operation, and of the high connected load sometimes requiring special wiring and higher electric rates.

In order to determine the characteristics and the relative energy consumptions of the different types of electric steam boilers, a series of laboratory tests was made by the authors on six different boilers, three of the accumulator type and three of the instantaneous type. All tests were made in a room where the air temperature was maintained at 40 F.

From the studies it was concluded that in selecting a boiler from the six tested on a basis of two sterilizing periods per day, the consideration of other factors such as convenience, electric rates, and initial cost is more important than the energy consumption. In selecting a boiler on the basis of one sterilizing period per day, the instantaneous type has a definite advantage in energy consumption. The efficiency of the accumulator boilers could be improved only by increasing their insulation, while that of the instantaneous boilers could be improved both by increasing the insulation and by reducing the amount of heat left in the boiler after the sterilizing operations are finished. The latter could be accomplished by designing the boiler so that a minimum amount of water is heated other than that necessary to furnish steam.

Urban Transportation

THE BALTIMORE ENGINEER

MOTIVATED by a general clamor and pressure to do something about urban street congestion, urban communities are indulging in too much hit-and-miss planning, changing, and construction, and are swayed in too many instances by political pressure from groups who expect to benefit at public expense, declares Charles Gordon, managing director of the American Transit Association, in an article appearing in *The Baltimore Engineer* for January, 1940. Cities undertake huge outlays for street improvements which may or may not be wisely planned, and which have a baffling way of becoming loaded beyond capacity almost as quickly as they are completed. And in the meantime there is a tendency to ignore the vital public carriers, such as streetcars, trolley coaches, buses, and subways, and to overlook many opportunities for improving their facilities and service in carrying out community traffic-improvement plans.

Surveys have been conducted on the problems of urban transportation by many groups. Brought out in these studies were many interesting facts, some of which are illustrated by the charts in Fig. 1. Shown here are: The relative capacity of a street for autos, buses, and streetcars; effect of "weaving" on street capacity; results obtained in separating grades; effect of speed on traffic capacity; comparison of the cost of subways and elevated highways; and the space occupied in buildings by workers and parking their autos.

Remarkably rapid progress has been made by engineers during the last five years in the development of improved vehicles for urban mass transportation. The bus was originally a makeshift adaptation of a truck chassis. Today, it leads rather than follows the development of the automobile. There seems to be every reason to believe that the rear-engine construction and automatic transmission of the bus will become inevitable in the private passenger car.

Crossbred between the bus and the electric car is the trackless trolley which had proved itself a valuable and useful vehicle for urban transportation. When the size of vehicle required reaches 40-passenger capacity, and the service conditions require frequent stops, the trackless trolley adequately meets the problem of providing sufficient power, by resort to the overhead trolley, while at the same time retaining to a considerable extent, the maneuverability of the bus.

Finally, the streetcar itself has undergone a complete metamorphosis. Starting in the fall of 1929 and continuing to the present date, a research program supported by 50 operating and manufacturing companies in the transit industry and conducted under the direction of the late C. F. Hirshfeld, past vice-president of the A.S.M.E., resulted in the development of the so-

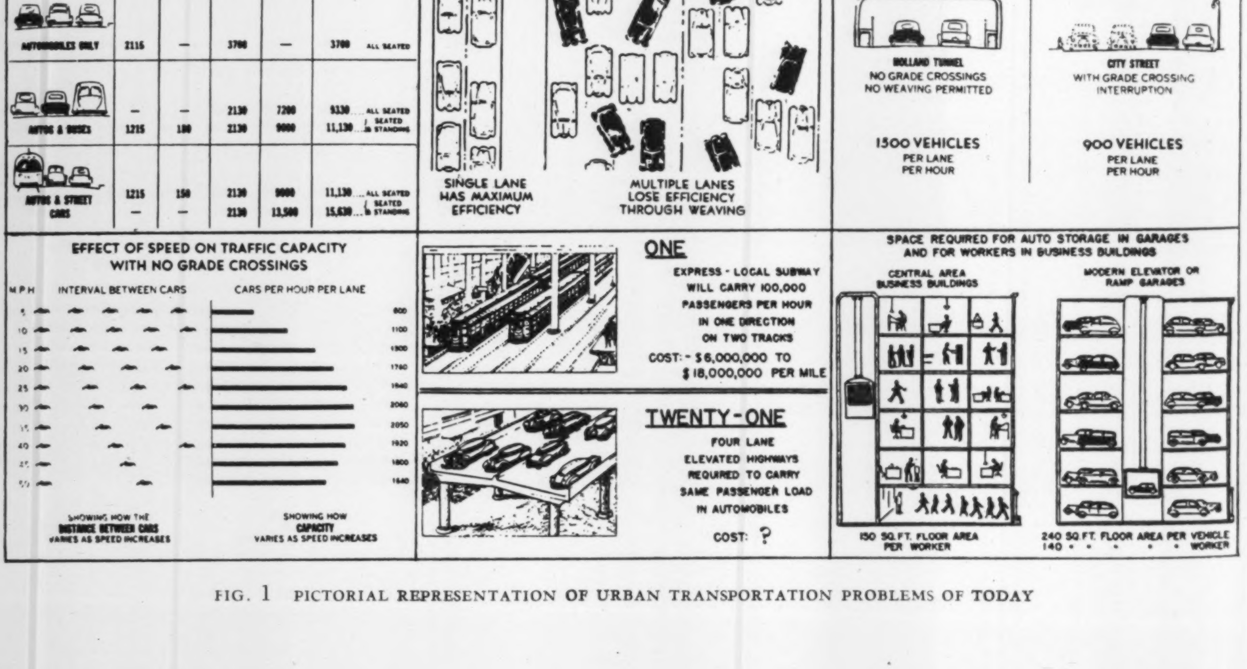

VEHICLE & PASSENGER CAPACITY - CITY STREET
60 FT PAVEMENT - 3 LANES EACH DIRECTION - NO PARKING
VEHICLE CAPACITY
PASSENGER CAPACITY
AUTOS
BUSES OR STREET CARS
TOTAL PASSENGERS
AUTOMOBILES ONLY
2115 — 3700 — 3700 ALL SEATED
AUTOS & BUSES
— — 2130 7200 9330 ... ALL SEATED
1215 180 2130 9000 11,130 ... SEATED & STANDING
AUTOS & STREET CARS
1215 150 2130 9000 11,130 ... ALL SEATED
— — 2130 13,500 15,630 ... SEATED & STANDING
SINGLE LANE HAS MAXIMUM EFFICIENCY
MULTIPLE LANES LOSE EFFICIENCY THROUGH WEAVING
EFFECT OF GRADE CROSSINGS ON MAXIMUM VEHICLE CAPACITY
HOLLAND TUNNEL
NO GRADE CROSSINGS
NO WEAVING PERMITTED
1500 VEHICLES PER LANE PER HOUR
CITY STREET
WITH GRADE CROSSING INTERRUPTION
900 VEHICLES PER LANE PER HOUR
EFFECT OF SPEED ON TRAFFIC CAPACITY WITH NO GRADE CROSSINGS
M P H
INTERVAL BETWEEN CARS
CARS PER HOUR PER LANE
5 10 15 20 25 30 35 40 45 50
800 1100 1300 1760 1940 2060 2050 1920 1800 1640
SHOWING HOW THE DISTANCE BETWEEN CARS VARIES AS SPEED INCREASES
SHOWING HOW CAPACITY VARIES AS SPEED INCREASES
ONE
EXPRESS - LOCAL SUBWAY WILL CARRY 100,000 PASSENGERS PER HOUR IN ONE DIRECTION ON TWO TRACKS
COST: - $6,000,000 TO $18,000,000 PER MILE
TWENTY - ONE
FOUR LANE ELEVATED HIGHWAYS REQUIRED TO CARRY SAME PASSENGER LOAD IN AUTOMOBILES
COST: ?
SPACE REQUIRED FOR AUTO STORAGE IN GARAGES AND FOR WORKERS IN BUSINESS BUILDINGS
CENTRAL AREA BUSINESS BUILDINGS
MODERN ELEVATOR OR RAMP GARAGES
150 SQ. FT. FLOOR AREA PER WORKER
240 SQ. FT. FLOOR AREA PER VEHICLE
140 " " " " WORKER

FIG. 1 PICTORIAL REPRESENTATION OF URBAN TRANSPORTATION PROBLEMS OF TODAY

called Electric Railway Presidents' Conference Car, commonly referred to as the P.C.C. car. Most notable achievement was the complete elimination of steel springs by the substitution of rubber.

In conclusion, Mr. Gordon says that engineers in particular have a great opportunity and a great responsibility in the field of urban transportation. Not alone as engineers, but as citizens of the community, they are in position to aid in the adoption of sound civic policies through their ability to understand the intricate problems involved. Urban transportation problems will be worked out not alone in the drafting room and the laboratory, but in the arena of daily life where the public is the judge and where economic and engineering data may be outweighed by visionary schemes which appeal to the popular imagination.

Low-Cost Housing Research

JOHN B. PIERCE FOUNDATION

IN ANSWER to the demand for modern, low-cost housing, the John B. Pierce Foundation, a nonprofit research organization dedicated to the betterment of human living, has just completed a five-room, experimental house in Lebanon, N. J., at a cost of $2632, including built-in furniture but excluding land and builder's overhead and profit. In both plan and construction it is a distinct improvement over the Foundation's preceding experimental house built in 1939. Eventually, it is hoped that a house will be developed which can be sold for $2500, including land and builder's profit. The engineers and architects of the Foundation have also come to the conclusion that standardization of smaller parts can provide factory-production benefits without the awkward handling encountered with heavy, large prefabricated units.

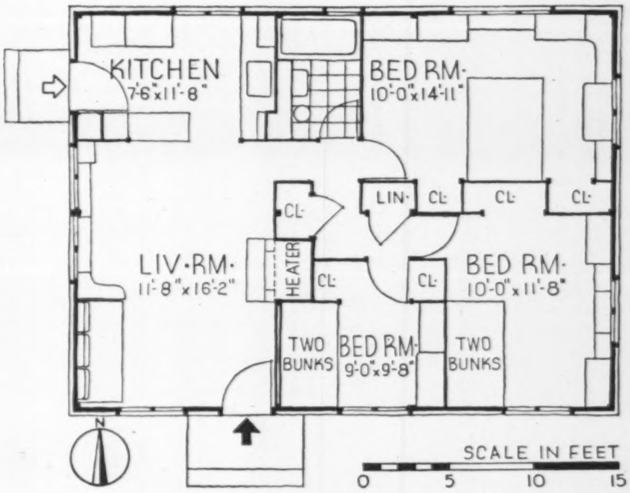


FIG. 3 FLOOR PLAN OF PIERCE FOUNDATION HOUSE

Since the economic features of low-cost housing were so well covered by articles appearing in Mechanical Engineering (November, 1939, page 781, and September, 1935, page 571, the latter being based on a symposium sponsored by the A.S.M.E. Wood Industries Division), only the technical details of the Foundation's house will be covered in this abstract, material for which was obtained from *Business Week*, April 13, 1940, and *The Architectural Forum*, April, 1940

After wood columns were set on concrete piers, structural exterior walls were built up horizontally in three operations: First, long waist-high plywood girders were set in place at the floor level; second, stock wood casement windows were separated by plywood panels into which they slide when opened, and third, atop these went another layer of plywood girders. A typical wall section consists of an outer panel of $^{5}/_{8}$-in. phenolic plywood, 1-in. fiberglass insulation, 1-in. air space, and $^{1}/_{4}$-in. plywood interior panels. The roof is constructed of rafters, plywood sheathing, and asphalt shingles.

Other improvements, which embody original ideas in engineering and design, are found in the kitchen, plumbing, and housekeeping equipment. Electrical items include a range, hot-water heater, and a cooled food chest. The cooking unit has a fryer whose element lifts up disclosing a recess that employs the same element for broiling, also a combination roasting pan and oven generous enough to take an 18-lb turkey. The refrigerated chest does not make ice cubes, but maintains sufficiently low temperature to preserve foods. An automatic water heater of 10 gal capacity provides sufficient water for two baths without reheating and for normal cooking or washing needs.

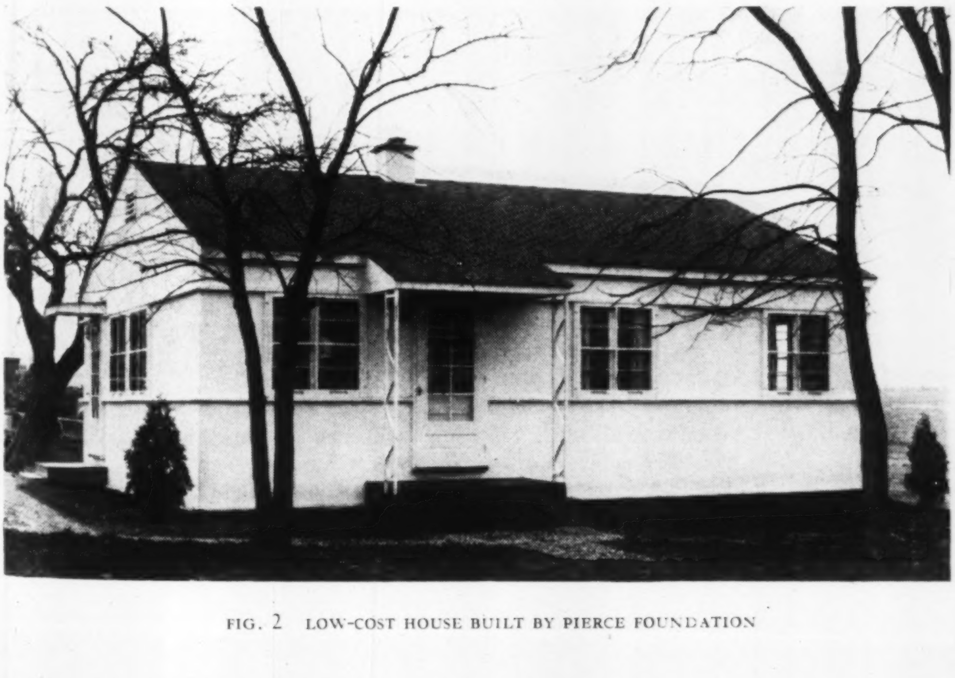


FIG. 2 LOW-COST HOUSE BUILT BY PIERCE FOUNDATION

To augment the water heater, the planners have developed a special automatic electric scrub bucket and electric teakettle. These plug into any outlet and shut themselves off when sufficient heat is attained. Also included in the house cost is a toaster, waffle iron, and coffee maker, all electric. Tests indicate that the average economical family can run this equipment for about $10 a month where the cost for current is around 2 cents per kw minimum.

The plumbing developments are interesting, too. Main feed and drain pipes are prejoined and are enclosed in steel enamel cabinets. These cabinets have built-in compartments for towels and medicines. They fit on top of each other with dowels, thereby forming a permanent part of the white bathroom wall. The pipes attach directly into all bathroom fixtures and into the kitchen fixtures which back up the bathroom wall. Special braces inside the cabinets furnish supports for the toilet and wash basin which are wall-hung, leaving the floor clear. The house is heated by a specially designed fireplace in the living room. It delivers warm air to bedrooms through short ducts, pulls in the cold air from the floor, and can be adapted to coal or wood.

As shown in Figs. 2 and 3, the house has over-all dimensions of 24 × 32 ft; the three bedrooms with sleeping room for six, the closet space, and the extent of the built-in furniture are some features absent from present-day low-cost houses. The Foundation does not intend to do any manufacturing or merchandising of these houses. Decisions shortly to be made may call for licensing manufacturers, dealers, and builders to use features developed in its research program.

Engineering and the Farmer

AGRICULTURAL ENGINEERING

ONE of the most important of all engineering factors in a balanced agriculture is to make everybody realize that agriculture cannot be properly balanced without the help of engineering, is the statement made by K. J. T. Ekblaw, president of the American Society of Agricultural Engineers, in an article appearing in the April, 1940, issue of the Society's journal, *Agricultural Engineering*. Balanced agriculture is defined by him as not only a balancing of certain farm activities, one against the other, with due regard to fair proportioning on individual farms, but also a balancing of agriculture against other industries which are operating within the same region.

The engineering problems of the farmer divide themselves mainly into three general classes. One is the conservation and enrichment of his soil, which constitutes a large portion of his capital. Another is the supply and maintenance of the necessary structures for housing family, crops, livestock, and home processing, another large capital value. A third is the supply and maintenance of his movable equipment, consisting of field and power machinery, haulage equipment, and building equipment.

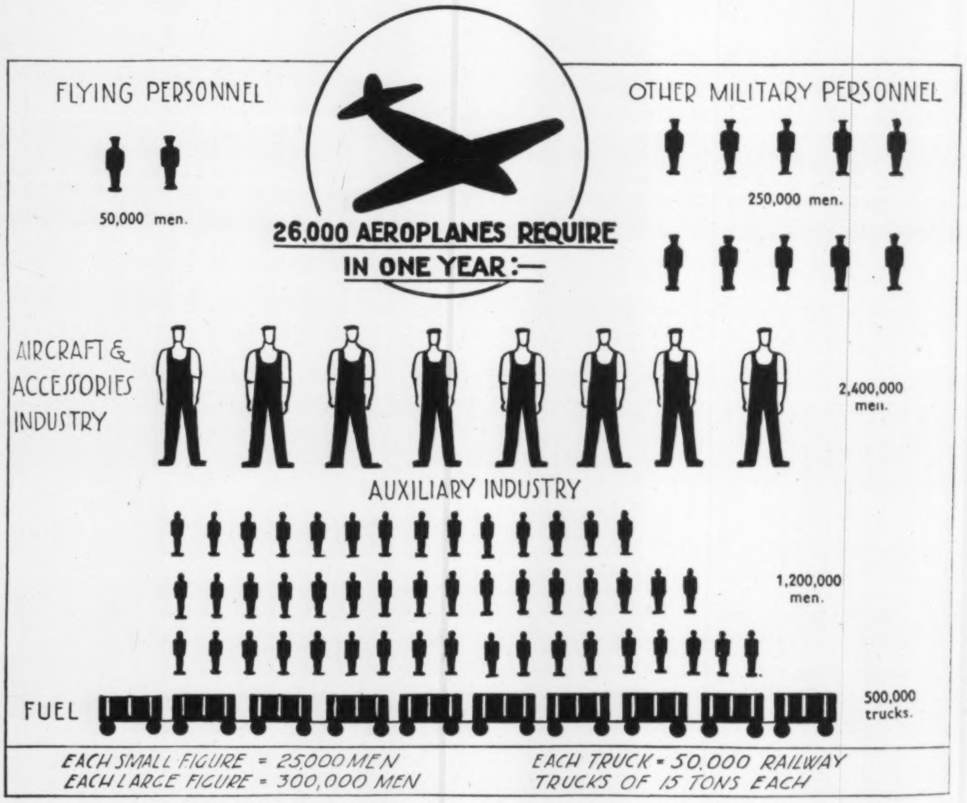
To these three, however, might be added a fourth class, namely, the development of the engineering principles and practices that will further the cause of agriculture, and their application to current farm operation. This involves the educational aspect of the problem, with emphasis on research, extension, and teaching. The establishment and operation of adequate technical schools, laboratories, and experiment stations is of vital concern to the farmer; and of equally vital concern is the need of effecting a complete and positive distribution of beneficial information developed at these institutions.

Portable Electric Generators

AMERICAN ENGINEERING COUNCIL

DIESEL-ELECTRIC generating stations mounted on trailers will be used to supply power for at least three rural electric systems financed through the Rural Electrification Administration, according to a recent announcement received through the American Engineering Council. Two such units are now going into service for the Jo-Carroll Electric Cooperative, an Illinois organization supplying 600 families through 278 miles of line.

Each portable unit consists of two Diesel-powered generators of 60 and 40 kw capacity, respectively, mounted upon a rubber-tired trailer. No building is required to house them and they may be connected to the power line at any convenient point through step-up transformers. Operation is semiautomatic, requiring only the part-time attention of one man.



PERSONNEL REQUIRED TO BUILD, MAINTAIN, AND FLY A WARTIME AIR FORCE WITH A PERMANENT BASIC STRENGTH OF 26,000 AIRPLANES

(This chart, reproduced here from an article appearing in the April 5, 1940, issue of *The Aeroplane* (London), illustrates graphically the personnel requirements of an air force of 13,000 combat planes and 13,000 noncombat craft of all-metal construction and an average gross weight of 10,000 lb. The total replacements per annum in wartime would require at least 117,000 airplanes and 221,000 engine units to maintain the basic strength. As shown, part of the man-power is used in the aircraft and accessories industry for research and the production of fuselages, engines, propellers, and instruments, and the other part in auxiliary industries for the production of fuel, lubricants, uniforms, and their distribution and transport.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Which Fuel to Choose?

Comment by Irving L. Nevells[1]

Engineers in the New York area should welcome this paper[2] with its clear and concise analysis of the various factors involved in the choice of fuel and fuel-burning equipment. The same analysis will be useful for engineers in other sections when the proper values are substituted for the available fuels.

The writer wishes to point out, however, the difficulty of establishing losses and the resulting efficiency for stoker firing with bituminous coal without taking the type of stoker into consideration. There is a wide difference due to the design alone without considering factors such as the setting or arrangement of heat-absorbing surfaces.

There are three broad classifications of underfeed stokers: (1) The single-retort, side-dump-grate stoker usually applied to boilers up to about 500 hp. (2) The multiple-retort dump-grate stoker for larger boilers. Up to a few years ago this type of stoker was extensively installed for industrial and utility loads but its application is now largely restricted to heating or other low-load-factor loads. (3) Continuous-ash-discharge stoker, with or without clinker grinders. This stoker with its continuous self-cleaning design is being installed in practically all of the large industrial and utility stoker-fired jobs today.

The losses and efficiency figures given for stoker firing by the author are apparently an average of what could be expected from the first and second classes of dump-grate stokers. The 4 per cent solid-carbon loss given in Table 1 appears a little high with average efficient dump-grate stokers and the grade of coal mentioned. This coal should not have an ash content over 7.5 per cent and the solid-carbon loss to the stack should not exceed 0.3 per cent. The remaining ashpit loss of 3.7 per cent would correspond to 32 per cent combustible in refuse. This would be too high to be classed as efficient operation unless the stoker is overloaded, in which case both the stack and ashpit losses would naturally increase. The 40 per cent excess air appears to be a fair average for dump-grate stokers. While these stokers are capable of high test efficiency with expert operation, the probable everyday operating efficiency will be lower due to the periodic cleaning or dumping and the skill required to perform this operation with minimum loss.

The superiority of the continuous-ash-discharge stokers is due to their self-cleaning feature which allows the operator to maintain continuous high CO_2 without disrupting the fuel bed by dumping or cleaning. The amount of solid carbon discharged to the ashpit still depends on the skill of the operator, but better than average operation is not required to produce results closely approaching test efficiency. It has been found that test efficiencies are approached as closely in everyday operation with this type of stoker as with powdered coal or oil.

Average combustible in refuse from 10 to 15 per cent is readily obtained in everyday operation. This would correspond to 0.9 to 1.4 per cent solid-carbon loss. From 25 to 30 per cent excess air may be maintained continuously. Many of the well-operated plants installed during the last few years are reporting 84–86 per cent efficiency in daily operation. These plants have continuous-ash-discharge stokers, water-cooled furnaces, and economizers or air heaters, or both.

The writer has taken this opportunity to point out the difference in stoker types and the effect this has on efficiency because this is a fact that does not appear to be widely known. The possibilities of the continuous-ash-discharge stokers are often overlooked and the analysis based on the engineer's experience with dump-grate stokers. Where the evaluation is close this may result in the selection of apparatus not justified by the facts and with dissapointing results.

Comment by J. S. Bennett[3]

Many boiler plants are designed on the assumption that good coals will always be economically available. Unusual conditions, such as coal strikes, war conditions, adjustment of freight rates, the increase or decrease of activities in certain industries, and the modification of the price structure of liquid or gaseous fuels have in many cases substantially modified or interrupted altogether the normal coal supply to a given plant. The frequent recurrence of this experience has caused power-plant designers to investigate more thoroughly the possibilities of making the plant suitable for a variety of fuels. The wisdom of this course may be illustrated by two cases.

Some years ago, one of the neutrals in the European war zone installed multiple-retort underfeed stokers to burn good British coals exclusively, and was deaf to appeals to consider other coals. Their supply of British coal has been reduced and the neutral nation is now faced with a hurried program for adapting the furnaces to its low-grade domestic coal.

On the brighter side is the case of a Philadelphia manufacturer, who designed for cheap coals water-cooled stokers and furnaces to provide him with almost unlimited latitude in coal purchases. He finds that his ability to burn troublesome coals makes possible the purchase of all coals to better advantage. During the coal strike last spring, he continued operations with a mixture of anthracite fines and low-grade bituminous coal, a fuel that would have shut down most plants in a few hours.

Comment by O. F. Campbell[4]

The economy of fuel-oil burning versus coal burning for industrial plants depends entirely upon the price of fuel oil and coal as fired. The average efficiency has but little bearing upon the economy.

Mr. Anbro shows in Table 1 that the efficiencies of average boiler plants using fuel oil are higher than with the average coal-burning plants. This does not appear to me to be entirely correct, inasmuch as the theoretical efficiency of coal-burning is higher than with fuel-oil burning and with proper supervision of coal-burning plants and oil-burning plants there should be a slight increase in efficiency when burning coal. The slight increase in possible efficiency when burning coal has but little bearing upon the economy of oil burning versus coal burning when the price of fuel oil as fired is less than the price of coal as fired.

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[1] Sales Engineer, Stoker Department, Westinghouse Electric & Mfg. Co., Philadelphia, Pa. Mem. A.S.M.E.

[2] "Which Fuel to Choose?" by Gosta A. Anbro, Mechanical Engineering, November, 1939, pp. 804–806.

[3] Stoker Engineering, American Engineering Co., Philadelphia, Pa. Mem. A.S.M.E.

[4] Combustion Engineer, Sinclair Refining Co., East Chicago, Ind. Mem. A.S.M.E.

With reference to the sulphur content of the fuel oil, it is usually less than the sulphur content of the coal. If the sulphur content of a fuel be a function of corrosion of air heaters and ducts, then there should be more corrosion when burning coal than when burning fuel oil. However, corrosion is not entirely a function of sulphur content, but rather is a combination of the sulphur content and the water vapor.

In so far as the future will find a lower quantity of fuel oil available in view of the new and more perfected oil-refinery operation, it is my opinion that the market will find for many years to come fuel oil available in many localities cheaper than coal. Crude-oil reserves are greater today than ever before and large power plants in the future will find appreciable quantities of fuel oil. There appears to be no shortage of fuel oil available for power plants in the New York area and there probably will not be a shortage for many years to come.

COMMENT BY M. I. KEARNS[5]

The author's Fig. 1 shows the extreme fluctuation in the price of fuel oil over a period of several years, and the steady increase in the price of anthracite during the last five years. Anthracite is leaving the steam plant for a better price market because of the development of the household stokers. Engineering developments are doing the same thing with fuel oil. The bunker-C we knew a few years ago has gone and today we have oil fuels which if briefly titled are no more identified than when we say a coal is between lignite and anthracite. This range may be narrowed by current development, but in the direction of poorer average grade. The catalytic and hydrogenation processes are supposed to rework the old fuel-oil range and cut it in half. The heavy half of course will still be called fuel oil even if it looks like tar and smells like sulphur. Enlightening comments on fuel oils were made recently by representatives of two oil-burner manufacturers.[6]

In his subdivision 2, Mr. Anbro has been too brief. This is where the question "What are we getting for our money?" is answered and I believe we must go into details.

Unburned combustible losses, in the exhaust gas or in the ashpit, reflect in order, design, operation, and lastly fuel. For example, a cheap oil-burner job, poor atomization in a furnace with a gas temperature entering the boiler bank of around 2200 F, even with excellent operators and fuel, will give in excess of 2 per cent unburned combustible loss. While with proper correlation of pulverizer and burner, or stoker and furnace, unburned combustible loss may be less than 1 per cent.

Radiation loss tells the effectiveness of the insulating materials encasing the unit. Fuel is a remote relation to radiation loss. Manufacturers of equipment generally show competitive figures based on capacities, which in turn are measures of the economics of the project. At rating, a unit evaporating 10,000 lb of water per hour will show 2 per cent radiation loss, while a unit evaporating 100,000 lb of water per hour will show 1 per cent radiation loss.

Excess air is principally a result of equipment design, age, size, and operation. The few per cent, say 5 or at the outside 10, commonly called a fuel differential is in part a practical equipment fuel factor and part convenience of expression. Good equipment in a good assembly includes economical excess air. Roughly, 15 to 20 per cent for big jobs, 20 to 30 per cent for intermediate, and 30 to 50 per cent for the smaller units.

In my remarks I tried to carefully separate fuel, operation, and equipment. Any or all can be good, ordinary, or intolerable. Any or all can be deceptive. The problem is in distinguishing and differentiating and in measuring carefully parts of complicated assemblies of material and data.

COMMENT BY R. R. FREDERICK[7]

In reference to this paper, we submit the following data gathered during the first year's operation on two steam generators, each rated at 40,000 lb steam per hour continuously, and fired with Taylor water-cooled stokers burning $^3/_4$ in. high-volatile slack coal mostly from the northern West Virginia fields. While the high-volatile low-ash-fusion coals proved most economical, operating tests were also run to prove the ability of the equipment to burn coal through the following ranges: Volatile, 18–39 per cent; ash, 6.3–12.8 per cent; sulphur, 1.46–3.54 per cent; F.T.A., 2125–2600 F; and Btu as fired, 12,800–14,200.

The facts presented in this discussion represent the average annual operating results as totaled and averaged from the daily log sheets, and are not compiled from any short-run tests unless so stated. The comparisons contained herein are given under the same subdivisions enumerated in the paper.

Cost of Fuel. Delivered costs into the plant per million Btu were $0.1346, as compared with Mr. Anbro's figure of $0.16 for barge delivery at New York harbor water fronts.

Effect of Fuel on Plant Efficiency. The average annual over-all efficiency was 83.5 per cent. Consequently, Mr. Anbro's figure of 80.5 per cent seems low by 3 per cent when referred to our water-cooled stokers in a completely water-cooled furnace and, of course, employing preheated air. Therefore, we find that the efficiency we obtain on our stokers is as good as that estimated for pulverized coal by Mr. Anbro. The temperature of the gas leaving the air heater, checked over a two-week period (March 1–15), was 337 — 93 or 244 F above room temperature compared with 300 F reported by Mr. Anbro. Under test conditions the following results were obtained: Efficiency, 86.16 per cent; gas and vapor loss, 10.84 per cent; unburned combustible in the ash, 1 per cent; radiation and unaccountable losses, 2 per cent. Based on the average efficiency obtained throughout the year, the estimated average losses are approximately as follows: Gas and vapor loss, 12 per cent; unburned combustible in the ash, 1.5 per cent; and radiation and unaccountable losses, 3 per cent.

Effect of Fuel on Steam and Power Consumption. (1) Our power consumption for handling coal from cars to pile and to coal hopper was 0.0215 kwhr per million Btu, which closely checks the figure of 0.02 kwhr given by Mr. Anbro in his Table 3. (2) The balance of our power consumption for stoker motors, forced-draft fans, lorry, panel board, lights, etc., was 0.483 kwhr per million Btu of fuel, which represents the total power required, except (1), and is still slightly under the power of 0.5 kwhr shown in Table 3 for pulverization on powdered-fuel installations.

Effect of Fuel on Repair-Material Costs. (1) Our repair costs have not been detailed to specific equipment but the total boilerhouse and coal-handling repair and maintenance costs were $0.00966 per million Btu for the first twelve months' operation. (2) Also, as a matter of interest we found that our total boilerhouse and coal-handling costs and fuel costs (but not interest, insurance, depreciation, etc.) amounted to $0.2048 per million Btu, and deducting $0.1346 per million Btu for fuel costs we found $0.0702 per million Btu to be the total operating costs above the fuel costs. Therefore, our fuel costs were approximately two thirds of the total operating costs, or operating costs were 52.2 per cent of the total fuel costs.

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[5] Engineer and Sales Agent, Pittsburgh Coal Co., New York, N. Y. Mem. A.S.M.E.

[6] Discussion by T. Gardner and J. A. Hayes of "Burning Various Types of Oil-Refinery Fuels," by A. L. Wilson, Trans. A.S.M.E., vol. 61, November, 1939, p. 702.

[7] Plant Engineer, Sloane-Blabon Corp., Philadelphia, Pa.

Effect of Fuel on Labor Requirements. Our labor costs for coal handling only were $0.00326 per million Btu, which falls well within the figures of $0.0025–$0.01 given by Mr. Anbro for coal and refuse handling.

Refuse Disposal. Formerly, ashes from the old plants were always hauled away free of charge, but with the new plant we are receiving at present a fair sum for exclusive rights (from one contractor) for all of our present stoker ashes.

Investment in Changed and New Equipment. In reference to Table 5 we would like to point out the figures previously mentioned; viz., that the 83 per cent efficiency shown for pulverized coal should apply also to our combustion equipment, and that the fuel costs involved were only $0.1346 per million Btu into our plant instead of the $0.16 shown in Table 5 for barge delivery at New York harbor waterfronts. Our low fuel costs may be accounted for by the fact that we were enabled to take advantage of spot coal purchases, and furthermore were not concerned with grindability factors or ash-fusion points.

Additional Data. Expressing our costs in terms of tons of coal burned we found that (1) total maintenance and repair costs for the entire plant were $0.2735 per ton of coal burned and (2) total plant operating costs (excluding interest, insurance, depreciation, etc.) per ton of coal were $5.80 or $0.2048 per million Btu, as previously given.

AUTHOR'S CLOSURE

Mr. Nevells' discussion of particular types of underfeed stokers is a valuable addition to the paper which gave only a broad outline of the whole problem. The important point of Mr. Nevells' remarks is that, in recent underfeed-stoker installations, the solid-carbon loss is distinctly less than it is for anthracite installations and not much more than it is in powdered-coal installations. However, the statement, that 0.9 to 1.4 per cent solid-carbon loss is readily obtained in everyday operation, certainly, does not apply to plants with frequent and large load fluctuations.

Mr. Bennett brings out an essential point in this problem, viz., to design for the greatest possible freedom in the fuel market. The importance of this may be better appreciated if we consider that a price change of 25 cents per ton of coal or 6 cents per bbl of oil is equivalent to an efficiency change of about 5 per cent.

Mr. Campbell's contention, that the economy of fuel-oil burning versus coal burning depends entirely upon the price as fired, is an exception rather than a rule. There are numerous examples of a considerable increase in efficiency when old stoker installations were changed to oil burning. In almost every case, oil burning shows some increase in efficiency in spite of the higher vapor loss. Savings in labor, repairs, and refuse disposal may or may not be negligible. The paper mentions many items which are practically negligible. These were included and evaluated because they are often given fantastic importance in sales arguments for some fuel or some equipment. Mr. Campbell's prediction that there would probably not be any shortage of fuel oil for power plants in New York for many years to come is rather ironical in view of the oil prices posted in New York since January.

Mr. Kearns' remarks on the importance of considering efficiency in detail contradicts Mr. Campbell's contention that efficiency has but little bearing upon the economy. In reply to Mr. Kearns the author can only say that he tried purposely to be as brief as possible. He agrees with Mr. Kearns that the problem requires careful analysis.

Mr. Frederick presented an interesting case history. A few more examples would make valuable supplements to the paper.

In conclusion, the author wishes to thank the discussers for their contributions to a better understanding of this complex problem.

GOSTA A. ANBRO.[8]

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[8] Superintendent of Power, Colgate-Palmolive-Peet Company, Jersey City, N. J. Mem. A.S.M.E.

Defining Equitable Limits of Dust Emission From Stacks

COMMENT BY WILLIAM G. CHRISTY[9]

It is to be hoped that this paper[10] will lead to a clarification of the air-pollution problem and enable smoke-abatement engineers to set limits of dust emission which will be equitable.

Some smoke ordinances prohibit the emission of fly ash, dust, or solid particles, the shade of which is equal to, or greater than, No. 2 and in some cases No. 3 as measured by the Ringelmann chart. Practical experience has shown that the Ringelmann chart is not suitable for measuring dust emission from stacks; it was designed only to measure smoke.

The tentative A.S.M.E. Power Test Code now gives three methods for determining dust loading of stacks and the efficiency of dust separators, but this does not solve the problem confronting a smoke inspector. Some of the larger plants may be equipped with a continuous sampler, as suggested by the author. Others may have facilities for making periodic tests according to methods recommended in the code. Let us assume for the moment that a smoke inspector may take and use the results of tests made by the plant. What about the vast number of plants which have no facilities for making any sort of a test? Perhaps we may make use of a small portable testing outfit. At present this would seem to be the best means of determining the dust loading of stacks.

In regard to particles larger than 20 microns being considered in the "nuisance range," this limit should be placed just as low as possible. Let us not lose sight of the fact that the very small particles cause a lot of damage. As to making higher allowable limits of dust emission from high stacks, I cannot agree with the author. As he states, the total dust emission is virtually unaffected by the height of the stack. Smoke inspectors and the public want a practical minimum amount of air pollution; to state it another way, we are interested in reducing the total amount of the dust discharged from stacks to a practical minimum.

The author's suggestion to fix standard temperature and standard CO_2 content for flue gases seems a reasonable one. The ash content of the coal used should be taken into consideration. From the standpoint of the public, we must not lose sight of the fact that it is the amount and character of the solid particles emitted which constitute a nuisance. The goal we are striving for is to reduce the emission of solid particles just as much as commercially possible. Doubtless many smoke regulations will soon include some limitation on dust loading of stack gases. There is a tendency to establish a weight limit per unit volume of gases. In establishing any limits, I feel that we should consider the covering power of the particles, as well as the weight.

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[9] Smoke Abatement Engineer, Hudson County, Jersey City, N. J. Mem. A.S.M.E.

[10] "Defining Equitable Limits of Dust Emission From Stacks," by P. H. Hardie, MECHANICAL ENGINEERING, December, 1939, pp. 895–896.

Comment by Howard S. Anders[11]

From the standpoint of preventive medicine, public health, and municipal sanitation, the dust problem is a vital one in relation to seasonal diseases and certain insidious affections like tuberculosis and rheumatic heart disease. About 70 per cent of heart-disease cases are due to rheumatic fever, which results from one or more varieties of streptococcus infections of the blood stream. This microbe, which enters the blood stream from infected throats, is inhaled and implanted by dust-borne streptococci.

It is a fundamental fact that dust is the common carrier of the common cold. Influenza, complications of pneumonia, and tuberculosis are all spread and aggravated by dust communicability. Hence, it is of vital importance to provide as dustless an atmosphere as possible in thickly populated areas if sickness and death rates are to be reduced.

Comment by J. Edwin Fulweiler[12]

We find in this paper the often repeated assertion that the emission from the many domestic stacks is in total more than that from the central and industrial plants, and the author suggests that some sort of control should be extended to the small user of coal if we wish to attain higher freedom from dust in the air.

We see no point in challenging the accuracy of this statement at this time, because it is so obviously true in some districts where dwellings are crowded together and factories are comparatively well scattered. Since it is in districts of that nature where regulation is important, we should not lose sight of the fact that the domestic furnace is operated almost entirely for heating and the dust emission occurs during the cold weather when winds are high and windows are closed. The result is that the atmospheric pollution from this source is much less noticed, and is actually less of a public nuisance than that from the factories and central plants which are contributing their dust on the hot still days as well. When the air currents are sluggish the cinders drop in the vicinity of the stacks and when the windows are open the lighter particles float in.

After discussing the possibility of fixing a limit of dust emission from stacks and the many factors which should be given consideration in defining this limit, the author suggests a very interesting method of providing for a check on the emission. The suggested arrangement for checking the emission merits consideration. It is such a great step over the usual procedure of not doing anything about it that the question of the accuracy of such a check is of less importance than the fact that a simple test arrangement is possible, which will at least give relative results and not put any great burden on the plant.

Comment by J. M. DallaValle[13]

Mr. Hardie has touched upon several items in his brief paper which are of much importance. First, he has brought up the problem of uniform test codes for dust-separating apparatus. This has been a much wanted code, and it is gratifying to know that the A.S.M.E. Power Test Code for Dust-Separating Apparatus, issued in tentative form in October, 1939, standardizes procedures for testing dust-separating apparatus used for the control of dust emitted from stacks. The code should find general application and will probably for the first time reduce dust-separating apparatus to a sound basis for comparison. Heretofore alleged efficiencies of dust-separating apparatus ranged from 90 to 100 per cent, depending on the type of test used. With the procedure as developed by the code, efficiencies will take on a new meaning.

The author also discussed the limits of dust concentration which are permissible. This obviously is a difficult problem and will probably require further attention, both by the Society and public-health officials. The claim that dusts emitted from stacks of power plants tend to create general nuisances and also to lower the amount of ultraviolet normally available at the earth's surface requires some consideration. There is no question with regard to the nuisance problem associated with dust, but the problem of evaluating the effect of such dust on health is open to some question.

The relative importance of these items will in the final analysis determine the limits of concentration which will be permitted to be thrown out of the stack. It may be well to point out here that with the more efficient control of flue dust there may be raised at some later date the problem of control of emission of certain gases such as sulphur dioxide; in fact, some health authorities have already turned their attention to stimulating some control of this gas.

Finally, Mr. Hardie stresses the need for continuous check on dust emission. This obviously cannot be governed by such a code as has been mentioned previously, but the need for checking equipment cannot be overemphasized. The experience of industrial firms in the control of the pneumoconiosis hazard has brought out the need for frequent checks. The equipment used for the control of dust is subject to considerable wear and tear, but more than this it represents a large item of expense which implies a constant need for attention. While no tangible returns are evident from the installation of dust-collecting equipment, they nevertheless produce a salutary effect on the community and reduce to a minimum the criticism so often leveled against power plants that they tend to pollute the air we breathe.

Comment by H. C. Dohrmann[14]

The inadequacy of merely limiting the concentration of dust in the flue gas emitted from stacks without due consideration of the factors outlined by the author can well be accepted as a reasonable conclusion. It is important, however, that any regulations which might be formulated to include these factors should be both simple in form and practical in application. This brings up the problem of correlating these ideas into a workable specification serving the interests of all concerned. This might well be accomplished by formation of a committee composed of representatives of the health authorities, the users of solid-fuel-burning equipment, and the manufacturers of dust-collector equipment to define such equitable limits and to act in advisory capacity to local authorities in the application of such definition to their particular locality and conditions. Such a procedure would bring about uniformity in the limitations imposed throughout the country.

The author's mention of stack height is presumed to refer to the elevation of the top of the stack above grade. However, if we are to consider this factor we must also consider the height of the boiler-house because this also has a bearing on the area of settlement. With a comparatively tall building and short stub stacks the flue gas discharged is influenced by the eddies in the wind stream on the leeward side of the building. It has been observed under such condition that particles of dust, which normally would not settle within four or five miles, are forced down and caused to settle within a much smaller radius. Relatively tall stacks raise the point of discharge above the disturbance of the wind stream by the building and are therefore more desirable, especially in congested localities. In this connection, it should be of interest to observe the future development of the so-called stackless boilerhouse in which short stub stacks are concealed in the building architecture.

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[12] Power and Industrial Engineer, Schmid & Fulweiler, Philadelphia, Pa. Mem. A.S.M.E.

[13] P. A. Sanitary Engineer, U. S. Public Health Service, Washington, D. C.

[14] Chief Engineer, Buell Engineering Co., New York, N. Y. Jun. A.S.M.E.

Particle size should most certainly be included to qualify the allowable dust discharge. In fact, we might dispense with the specification of total quantity of dust and instead limit the concentrations of particles larger than certain sizes. Such a stipulation would have the advantage of keeping at a minimum those particles which cause a nuisance, while at the same time it indirectly limits the total discharge, since any collection equipment which would reduce the stack emission to comply with the foregoing remarks must necessarily reduce the loading of particles smaller than 20 microns. In illustration of this point, consider a typical pulverized-fuel-fired boiler which would have a normal discharge of about 2 grains per cu ft corresponding to 400 F and 14 per cent CO_2. The size analysis of the dust would be approximately: 15 per cent (0.3 grain per cu ft) larger than 44 microns, and 40 per cent (0.8 grain per cu ft) larger than 20 microns.

Since properly designed collection equipment will have an efficiency of at least 99.5 per cent for the summation of particles larger than 44 microns and at least 98 per cent of all particles larger than 20 microns it would be possible to reduce the concentration to 0.0015 grain per cu ft of particles larger than 44 microns, and 0.016 grain per cu ft of particles larger than 20 microns. The concentration of particles smaller than 20 microns would range between 0.1 and 0.5 grain per cu ft, depending on the size and type of collector. A study of this method will disclose a flexibility of application not apparent in the present limits. Such flexibility is necessary due to variance in size distributions and loadings of dust met with in different types of boilers and the comparatively fixed particle-size efficiency characteristics found in collection equipment of a given size and manufacture.

The average dust emission over each 24-hour period would be a convenient basis of limits. However, this might tend to discriminate against the public-utility station having a more or less constant load to the favor of the industrial power plant which may have a load of considerable variation over the 24-hour period. Thus, if we are to use the average emission as a basis, we must compensate in some way for the boiler which is operated at reduced rating a considerable portion of the time. This is particularly significant with stoker-fired boilers where the dust concentration varies considerably with the boiler load.

It is evident that this paper is a truly rational approach to a difficult problem and I believe that further consideration along these lines will produce specifications compatible with the conditions existing and the equipment available.

COMMENT BY A. W. ROBINSON[15]

The author states: "Because less annoyance is caused by small particles there is a movement which started in Europe to define the nuisance range for flue dust as those particles larger than 20 microns in diameter" and Mr. Dohrmann assumes in his comments that this is an established fact. I should like to know whether there are any reliable data to support such a statement, as my own experience, and that of my company, has been entirely to the contrary. It has been our experience that dust finer than 20 microns is just as dirty—in fact is much dirtier—as is an equal weight of coarser dust.

As far as visibility is concerned, while granted that a single particle of less than 20 microns is harder to see than a coarser particle, it is pretty definite that the index of visibility is the surface area of the dust in the gases, and a pound of dust averaging 5 microns in diameter will have approximately four times the surface area and be, consequently, four times as visible as the same weight of 20-micron material. To support this statement, I personally have tested one of the most objectionable stacks in my experience to find the dust in it to be 100 per cent finer than $7^1/_2$ microns.

The most serious complaints ordinarily come from points at considerable distance from the offending plant, and it is usually only the minus-20-micron particles which travel that far, so that we believe that the finer particles cause more complaints than the coarse. Therefore, it is our belief that the minus-20-micron particles are far more nuisance than the coarser particles, and if anyone has any reasonable data to support the theory that 20 microns diameter is the lower limit of nuisance, it should be presented promptly and conclusively so that we may have our erroneous ideas corrected. On the other hand, if such data cannot be presented, it seems only reasonable that such classification be omitted from consideration.

COMMENT BY HUDSON H. BUBAR[16]

Mr. Hardie's paper deals, in general, with a subject which has confronted every person interested in dust elimination. Naturally such a paper must be brief to the point of omission of many important factors. I am in accord with him in many of his statements, but question others. Regarding the over-all efficiency of separation, which, I believe, he intended to apply to fly ash only, I would say he is inclined to be optimistic. Personally, I believe there are very few fly-ash installations averaging, under all operating conditions, even 80 per cent.

To base the permissible limits of emission on the weight of fuel burned would appear to have several stumbling blocks, such as percentage of ash in coal and percentage of carbon in ash, both of which would necessitate constant adjustment, as both are continuously changing, particularly the percentage of carbon in the ash.

It would also appear that the operation of a single sampler for the purpose of continuous check would offer such difficulties of accurate control as to render the results inconclusive, certainly in the smaller plant operating under broadly varying conditions. Even in large central plants the conditions of change in load, fluctuating velocities, and shifts in points of dust stratification would not give any correct quantitative answer.

Likewise, there must be considered the factors of operation connected with the continuous unit. Unless under constant supervision to meet and combat the wide variation in operating conditions and, in addition, unless controlled by various recording instruments, any sampler so installed could not be depended on. It might be well to consider just how the predetermined position of mean value could be established and how it could be guaranteed to give the correct answer under various operating conditions such as shifting loads, changes in CO_2, and gas temperature.

No matter how fine the dust, decided dust stratification and concentration will be found and, with changes in velocities, changes in damper settings, or changes in temperature, the points and conditions of dust stratification will fluctuate, thereby rendering inconclusive results.

It is true that all bases of determination, as used at present, tend toward penalizing the better operated plant. On the other hand, what operating condition exists without direct or indirect penalization of one sort or another and just how important would be this penalization, as compared to possible penalizations set up in other directions? If we are to consider high stacks, CO_2, and general location, we must also consider temperature, terrain, and prevailing winds, any one of which offers a distinct penalization.

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[15] Western Precipitation Corporation, Chicago, Ill. Mem. A.S.M.E.

[16] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

After all we have a certain problem, this problem being a general improvement in the dust conditions at present existing in our larger cities. The tendency, not only of the public but of the large operators themselves, is to consider only the larger offenders. Little thought appears to be given to the fact that total cleanup of all public utilities and industrial power plants would not completely solve the problem.

Recent surveys by the WPA reveal that even in concentrated industrial districts such as Pittsburgh, the total industrial nuisance contributes not more than 20 per cent of the total dust precipitation. When averaged in tons per square mile for the entire city, this precipitation varies from less than 40 tons per square mile in the summer months to almost 100 tons in the winter months. Less than half of the total summer precipitation can be attributed to industry, whereas 80 per cent of the winter precipitation is due to domestic and commercial heating plants. Practically nothing has been done to control this condition, in Pittsburgh or elsewhere.

We must not lose sight of these facts in our consideration of the nuisance factor. We must remember that costs of equipment and tests which can readily be borne by a large central station would be prohibitive in the average industrial plant, and out of the question with the small manufacturer or heating plant. Therefore, the means of determination of a dust condition should be as simple and economical as possible. Elaborate apparatus is not necessary in any case and elaborate tests are necessary only in few cases.

The main issue is not whether a certain piece of apparatus functions at 80 or 81.75 per cent. It is not whether 1 or 1.5 per cent of the plus-10-micron material is escaping. The main issue is that a dust nuisance exists in a hundred different forms and must be combated in a hundred different ways.

The Smoke Prevention Association analyzed the ordinances of 77 cities. Of these, 33 had some sort of a provision against fly ash; of the 33, 18 had no provision of enforcement, nine required only screens on top of the stack, and only six appeared to have requirements for the installation of dust precipitators. In no case can be found provision for rectifying the greatest source of the nuisance—the domestic load. Also, in no case has any concentrated effort been made by the engineering profession dealing with dust problems, by enforcement officials, or by others, toward the solution of this, the greatest dust problem of all. It has been neglected, either through ignorance of the condition, or because of the political attitude or because of lack of funds to carry on the work.

As previously stated, concentrated pressure is being put on the large offenders even to the extent that unfair action is often encouraged. But anyone who has given serious consideration to the problem knows that with every industrial stack in the country cleaned up 100 per cent we will still have a serious dust and smoke hazard in our cities.

By all means clean up the industrial nuisance. It is a step in the right direction. It will reduce the condition to a certain extent. But, to ignore the remainder of the problem as has been done in the past means failure in accomplishing any great improvement of conditions. If, and when, and after the industrial problem has been rectified, there will still be a decided dust and smoke nuisance, and industry will still be blamed for the nuisance unless the public is educated to the true facts and remedies inaugurated.

COMMENT BY A. W. ANTHONY[17]

The author's concrete suggestions as to continuous sampling and limiting the percentage of the ash that may be discharged continuously on the average is certainly more in line with both the public interest and the present possibility of accomplishment than is a definite limit of dust concentration at any moment.

One item not mentioned was that lung damage has been rather definitely related to the finer dust particles in the range below 10 microns. Therefore, from the viewpoint of public health, it is not sufficient to restrict dust removal to particles large enough to fall in the immediate vicinity of the stack, even though these may be the immediate cause of complaint.

The author stated, "eighty-five per cent over-all efficiency of separation is still a value obtained by but few installations day in and day out." This prompts the writer to forecast easily attainable increase in efficiencies of the scrubbers described[18] by M. D. Engle before the A.S.M.E. in December, 1936. These scrubbers were designed and built in 1930 and little has been done to improve their performance since 1932. Since then knowledge of the art of designing scrubbers has increased by leaps and bounds, so that much better efficiencies can now be attained by the use of more nozzles of smaller orifices. The scrubbers have been operating with nozzles having $^3/_{16}$-in. orifices with full-load efficiencies of 80 to 82 per cent. If double the number of nozzles of $^1/_{16}$-in. orifice were used, the efficiency would rise to 88 per cent at full load compared with 80 per cent at present, while the quantity of water would be reduced to one fourth of the present amount, with comparable reduction in cost of power for pumping; if three times as many were used, the efficiency would rise to 93 per cent, with 38 per cent of the water. If the average dust loadings were appreciably heavier, more water would have to be atomized, approximately in proportion to the dust loading, other things being equal. I wish to stress the point that, with a given scrubber already installed any desired efficiency can be attained by installation of adequate number of nozzles of suitable size.

Sufficient experimental work has been done, and checked by actual installations in industrial plants, to prove the foregoing. For instance, recently a pilot-plant scrubber was designed to catch a very fine chemical fume, said to be 0.5–1.0 micron, the loading known to be about 17 grains per cu ft; a set of fine nozzles was specified and it was predicted that satisfactory results would be obtained with nozzle pressures somewhere between 200 and 500 lb per sq in. We were gratified to learn from the operators that "satisfactory cleanup" was obtained at 300–350 lb per sq in. When full results came along later, we learned that some entrainment still persisted, but that, nevertheless, the efficiencies were 95–98 per cent, although the fume particle size was reported in the range of 0.5–3.6 microns.

COMMENT BY H. B. MELLER[19]

These remarks will be confined principally to consideration of the first sentence in the second paragraph of Mr. Hardie's paper: "Although this paper deals mainly with the problem of dust emission from central and industrial plants, it should be recognized that some form of control must be extended to the small coal consumers if we wish to attain considerably higher freedom from dust in the air."

Smoke-abatement ordinances, until recently, were directed against visible smoke only. In their formulation, it was easy to focus attention upon the comparatively few large users of coal. Plants in this group have engineers competent to look after combustion troubles when they occur. They and the management know that a smoky stack is an indication of waste and money loss. Therefore they are selfishly, if in no other way, interested in cooperating with city officials.

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[17] President, Pease Anthony Equipment Co., Cambridge, Mass.

[18] "Pease Anthony Gas Scrubbers," by M. D. Engle, Trans. A.S.M.E., vol. 59, 1937, pp. 358–360.

[19] Managing Director, Air Hygiene Foundation of America, Inc., Pittsburgh, Pa.

The intermediate and small-size industrial plants and the heating plants (exclusive of private homes) that operate seasonally are much more of a problem to the smoke-abatement official. Usually there is no incentive for highly efficient combustion of fuel nor, in general, with low-pressure plants, the equipment to attain it in normal operation. This condition is being improved as cities require automatic stokers or the use of smokeless fuel in small boilers.

In the dark background of the picture is the great number of private homes burning high-volatile coal in boilers and furnaces not designed for smokeless operation. Most antismoke ordinances exempt this class from regulation; where it is not exempt, the city's enforcement staff is too small to do much about it.

The comparatively recent activity toward control of fly ash has also been aimed largely at the big stack. Mr. Hardie has well covered this part of his discussion. The high stacks are potentially much greater individual offenders; they do, however, make for much greater diffusion. They are much easier for the smoke inspector to check. Then committees of the Society prepare excellent codes for sampling of various kinds to determine extent of pollution. Such methods, while of great value in the plants that can afford to make them, have had an undesirable psychological effect in that, being tied in closely with smoke abatement, they unintentionally bring further emphasis on the large stacks, with resulting de-emphasis on the smaller fellows who, in the aggregate, produce by far the greater part of the winter air pollution.

With the tremendously increased consciousness of urban air pollution and the many new and renewed efforts toward its control, there is need for the best advice and guidance obtainable if resultant ordinances and their enforcement are to be both effective and fair. This is clearly a job for the experienced engineer. Committees of engineering societies and associations should prepare a manual which, in simple language, will tell the government and the citizens of any community how the air pollution problem can be controlled, whether the fuel user burns a million or more tons a year or five tons during a winter. The manual should set reasonable limits for permissible smoke and fly ash, give methods by which the smoke-abatement bureau can determine violations, and give to each class of plants its proper place in the scheme.

AUTHOR'S CLOSURE

The foregoing discussions could well be called a symposium on the cause, curse, and cure of air pollution resulting from the combustion of fuel. The viewpoints of manufacturers and users of dust-separating equipment, smoke- and dust-enforcement officials, and health and medical authorities have been presented in a clear and forceful manner.

The discussers have enlarged upon the scope of this paper which was confined to the emission of solid particles from stacks. Although, strictly speaking, smoke consists of solid particles, those particles are usually smaller than 1 mu in diam. As distinguished from flue dust, smoke is the result of incomplete or arrested combustion of the volatile constituents of fuel and contains no ash. The emission of smoke may be gaged optically but the emission of flue dust must be gaged on a weight or volume basis. Even dust counts in stack gases have little or no significance because of the wide range in size of particles.

With few exceptions, the discussers seem to agree that most of the factors outlined in the paper for consideration, before establishing limits of dust emission, are at least desirable if not absolutely necessary. The greatest disagreement arises from a consideration of particle size. Mr. Dohrmann not only advocates acceptance of a nuisance range based on the size of the dust particles but also suggests that, by establishing limits of dust concentration for the larger-size particles, we might dispense with consideration of the total quantity of dust emitted. His example of how this basis would work applies mainly to dust separators of the cyclone or trap type, and would prove satisfactory, even with these types, only when the proportion of very fine particles did not become excessive. Some of the other types of dust separators, such as the electrostatic, are more efficient with small-size dust particles, and might show up poorly on the basis suggested by Mr. Dohrmann, even though their over-all efficiencies were excellent.

Messrs. Christy and Robinson seem to feel that, for the same dust concentration, the smaller the dust particles the more nuisance they are likely to cause because in aggregate their covering power is greater. Mr. Robinson reports that one objectionable stack was tested and found to have no dust particles larger than $7^1/_2$ mu, which would seem to indicate that 20 mu is too high for the lower limit of the nuisance range. It is difficult to visualize any plant with reasonably efficient dust-separating apparatus causing serious complaints from points distant from the plant. There are of course exceptions to all rules. In answer to Mr. Robinson's question regarding data to support the 20-mu limit for the nuisance range, the author is able to state merely that, it has been reported, complaints usually ceased when dust-separating apparatus was installed which removed virtually all of the particles larger than 20 mu.

A simple continuous sampling method for determining dust concentration seems to have met with approval from Messrs. DallaValle, Fulweiler, and Anthony. Mr. Dohrmann seems to feel that, while the idea is good from a practical standpoint, it would work to the disadvantage of plants having a more or less continuous load. This, however, would not be the case because the quantity of gas sampled would be proportional to the load. The average dust concentration would be computed by dividing the total dust caught by the total gas sampled. It should not be computed by averaging the dust concentration for individual hours or for other periods, some of which might be for low load or a banked condition. The author did not make this point clear. Mr. Bubar feels that the results obtained with a continuous sampler would be too unreliable to be of value. The author feels that the difficulties enumerated by Mr. Bubar could be overcome in most cases.

The opinions regarding the proportion of the total dust in the atmosphere which is attributable to small and large coal consumers is interesting. Mr. Fulweiler injects the opinion that dust is less objectionable in winter than in summer. Even assuming this to be true, it does not seem to constitute sufficient grounds for exempting the small heating plants from conforming to a code, even though the code might reasonably be less exacting for such plants.

It is hoped the suggestions of Messrs. Meller and Dohrmann, that a national committee, consisting of representatives from each of the interested groups be formed, will be heeded, and that such a body will be able to provide the advice and guidance necessary to assure the establishment of equitable limits of dust emission in all codes.

In conclusion, the author wishes to

thank all of the discussers. Much additional information and many valuable suggestions have been contributed by them.

P. H. HARDIE.[20]

Unionization of Engineers[21]

TO THE EDITOR:

Mrs. Charles Lindbergh, in a preface to "Wind, Sand and Stars" by the French aviator St. Exupery, says, "A mother does not lie when she calls her child 'my golden one,' " and quotes the great Russian novelist Chekhov in saying, "One must not humiliate people—that is the chief thing. Better say to a man 'my Angel' than hurl 'Fool' at his head—though men are more like fools than they are like angels."

By contrast, the attitude of the normal successful engineer toward labor unions is pathological. When we mention lawyers and their work we do not think it necessary to refer to the generally recognized derelictions of a considerable number of the members of that profession or the fact that even judges go wrong from time to time. When speaking of doctors the impression is given that we vision them all as the kindly, competent, hard-worked general practitioner of our youth rather than the present-day urban specialist, of whom some are more businessman than high priest. Even those of us who see some merit in labor organizations are apt to begin our comments by deprecating "union excesses." Those less favorably inclined play safe by excepting Sydney Hillman and the railroad brotherhoods from their criticisms. This appears like an unreasonable approach to any rational discussion of an important and inevitable social phenomenon.

I spent the first half of my adult life, if not opposed to labor organizations, at least highly critical of their then quite common practice of restricting output. The Great War taught many lessons to the alert. I know of no group that has more richly profited by those experiences than the labor unions. In the 20 years since the war I have become more and more convinced that organized labor is a useful social institution. In fact, I wonder how we can safely and surely reach higher democratic levels without the unions. Of course if we do not desire to perpetuate, develop, and spread our democracy, any such discussion as this is wholly useless.

To my way of thinking, if churches, luncheon clubs, professional societies, educational institutions, labor unions, and business organizations are to be useful social agencies, they will in some measure share their objectives; at least be pointed in the same general direction, be fellow travelers in a sense. To think otherwise would make the public weal and progress far more haphazard than history and science prove it to be.

We in the A.S.M.E. belong to a professional society. The census taker says so. About sixty years ago he would have said that civil engineering was a profession, but he had no place on his blank for mechanical engineers. Some of us looked to him quite like high-grade plumbers. We are coming up as far as the census taker goes. But whether we have characteristics and attitudes appropriate to a genuine professional status is an individual matter. Some of us have, but many of us have not.

So it is with labor unions. Time was when any association of workers was illegal throughout the civilized world. Union members were hunted down as were my Welsh forebears for being Quakers. But these outlawed unions grew in strength, and with added social status has come an increasing sense of social responsibility. As with engineers, the contribution of the individual member to the objectives of these organizations varies widely. Both unions and engineering societies have drones in their membership—to put it mildly.

Some workers belong to a union only—not even to a church. Some engineers do not belong even to an engineering society. Some of us, however, belong to a number of organizations, each one ministering to us in one way or another. Or to put it differently, we find that we can do our bit through one agency more effectively than through another. But, if these organizations are headed right, membership in one should not exclude you from another. I am a management engineer, something of an economist, a political scientist, an Episcopalian, an educator, a traveler—on occasion, a fraternity brother and belong to organizations appropriate to each. I might also belong to a labor union—either the machinists or the writers guild. Membership in a professional society and in a labor union do not seem to be mutually exclusive.

The main present-day objective of unionism is to facilitate collective bargaining with an employer and thereby safeguard and improve individual and group status. I do not happen to need this. But the great majority of A.S.M.E. members do. There are fraternal aspects to union membership which engineers might use. Before me lies a letter from a brother engineer, broken in health and fortune, asking me whether I know any engineering agency which might succor him. Of course there are none such. But if he were a pressman or a steamfitter, a typesetter or an actor, relief would be his for the asking.

Finally, it is a sobering thought that we engineers are concerned almost exclusively with material things. We have resisted thus far—as the scientists have—assuming much responsibility for the bearing of our work on individual freedom or the betterment of human society. Gains such as these from our work are incidental—not a driving force. And yet, as said recently by geologist Mather of Harvard in a Sigma Xi lecture, "the only chance for mankind to succeed . . . . is through progress in the art of living on a high spiritual plane."

Yes, if you must criticize the unions, being human they do on occasion disappoint us in seeking "narrow and selfish objectives." At times they adopt what to some seem like crude methods. Where force is used it is almost always against unbelievably obstinate economic, political, civil, and spiritual oppression. Since the early days the unions have single-handed, and frequently against the opposition of the educated classes, battled effectively for human freedom and the underprivileged.

The engineer as wage earner need make no excuse for allying himself with a labor movement driving forcibly and inevitably toward a more peaceful, more tolerant, and more secure cultured life for all the people.

MORRIS LLEWELLYN COOKE.[22]

TO THE EDITOR:

There has been considerable discussion in your columns pro and con on the subject of unionism for professional engineers, and protagonists with different backgrounds have advanced strong, convincing, but opposing arguments upon the subject, mostly obviously inspired by their own immediate personal status in relation to the matter.

Perhaps the views of an engineer who has had an intimate experience of forty years as technician, executive, educator, and industrialist, one who has no ax to grind, no grudge to pay off, in fact no strings whatever tied to him except, perhaps, a love for, and a pride in, his profession, and a sincere wish for the welfare of his fellow engineers, owing no man for any favors, belonging to no political party, and free to call a spade a spade without let or hindrance, might find a place with the other letters upon the subject. Coming from such a one having a long standing and busy membership in national technical, professional, social, educational, and military engineering associations and experienced in nearly every phase of engineering and several of its classifications and with an active acquaintance with labor, industry, public-utility, and government agencies in their engineering aspects, such a letter might be felt to have a broad impartial professional engineering viewpoint stated in a cold, impersonal way.

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[21] A seventh group of letters commenting on an article "Unionization of Engineers," by James H. Herron, MECHANICAL ENGINEERING, vol. 61, November, 1939, pp. 788–789 and 822.

[22] Philadelphia, Pa. Fellow A.S.M.E.

Having thus briefly presented qualifications and without taking up a detailed discussion of all that has gone before but striking directly to the heart of the question, it is submitted that we should first break the problem down or divide it into separate questions for proper analysis. Obvious questions follow:

1 What is the basic question—unionism *or* professionalism?

2 Is unionism needed or desirable (*a*) for the individual professional engineer? (*b*) for the profession of engineering? (*c*) for the social and industrial structure of the nation?

3 What are the causes of the inception of the unionization idea?

4 What are the factors behind the aforementioned causes?

5 What will increase and enhance activities toward unionization growth and what will have a retarding effect?

Now let us consider the foregoing questions as impartially and as analytically as possible:

No. 1. What is the basic question—unionism *or* professionalism? No, that is obviously not the question. There is not necessarily a question between the two. Professional men can unionize. It can be unionism *and* professionalism. No, the real question is simply unionism. A unionism that takes in every Tom, Dick, and Harry who have the remotest claim to technical ability in its broadest sense or who, after years of muddling along on various technical jobs, without professional qualification would ascend financially by pulling down the more capable and successful engineers to their lower grade which they, without professional pride, would place on the level with technicians and trade workers.

The question of unionism *or* professionalism is only for those of professional attainments, not for those whose attainments fall short of such attainment. It may be safely assumed that those of proved professional qualifications will, in the main, never debase their professional standing, will never consider unionism for the profession unless forced into it by conditions that they cannot avert, engendered by labor groups on one side and by employer action on the other.

The professional engineer during the last decade has been emerging at a rapid rate from obscurity and growing in public recognition and esteem. It is hoped that his emergence will develop along the lines best for himself, his profession, and the economic and social structure of his nation.

No. 2 (*a*). Is unionism of professional engineers needed or desirable for the individual professional engineer?

For the successful engineer, it is but remotely possible that benefit could accrue from union membership, but by it, he would be subjugated to the mass voice or authority of a union of technicians, or worse still, to a union boss. This would not be conducive to his further development, advancement, or independence of thought.

There is a prevailing and increasing school of thought among the better-able engineers that engineering is an accepted and responsible profession which should not be debased by banding in with technicians, draftsmen, and other skilled workers in the trade groups and alliances, also that a capable engineer in an engineering capacity can obtain a commensurate salary in private employ. The inadequacies of public-servant salaries for engineers does not enter the union question. That necessitates a keener recognition on the part of the general public and government agencies of the value of engineering services and by this is not meant merely the compensation value.

No. 2 (*b*). Is unionism of professional engineers needed or desirable for the profession of engineering?

Consideration would indicate that it is neither. The profession, depending upon individual and collective effort for its advances in scientific development, research, invention, and productive advances, would undoubtedly suffer should it become subservient to union rule and regulation. This implies no quarrel with unionism in its proper field and function. Unionization may be advisable for technicians, draftsmen, chemists, and other operators of like ilk, whose duties are more or less routine and which are fixed on approximately standardized levels, but that is not our question as members of the engineering profession.

The effects of unionization, should it ever become operative in the profession, would be felt as a retardant force in our universities and against the advancement of our young engineers who would indubitably be restricted in their expansion and development during their post-graduate qualifying and training period by union regulations and confined to a narrow scope of activity, as is now effected by existing trade unions in their particular spheres. The net result to the profession as a profession would logically seem to be certain to become reactionary and disastrous.

No. 2 (*c*). Is unionism of professional engineers needed or desirable for the industrial and social structure of the nation?

Why should it be? Anything restrictive placed upon the constructive and mental talents within a nation needs must retard its development and react unfavorably upon the conditions of its people. It must be admitted from past experience that unionism has been restrictive as to apprenticeship, productivity, fields of activity, and in admission to the right to obtain employment. The only restriction the profession of engineering should have is lack of learning, training, and innate engineering ability. This restriction should be made more effective at the present time by more careful engineering-school entrance requirements and weeding out after entrance of the poorer engineering material. Men lacking native engineering talent and aptitudes should never be qualified as professional engineers and a union card can never make a man a professional engineer.

National interest demands that the profession be maintained at its highest intellectual efficiency; union labels on it are no guarantee of that. There is a well-grounded feeling that the professional engineer should be a sound and neutral factor in discussions between employers and employees, or as we so frequently hear, between "capital" and "labor." The properly trained factual engineering mind is considered well fitted for impartial and judicial arbitration or compromise, and for this reason it should be withheld from the domination of union rule and partisanship for the best interests of humanity within the nation.

However, merely for the basis of consideration, let us suppose that the engineering profession did unite in a powerful union dominating all technical workers. Can you remember a few years back when a few idealistic (to use a mild term) individuals received world-wide free advertising for their scheme of "technocracy" and were known as "technocrats?" What is the difference between that and the proposed unionization? Most probably, if such a union were possible of accomplishment, it would become the most powerful factor in the world, it would "outguild" the guilds of medieval times. Being an organization of the creative, planning, and producing minds of the nation, its possibilities for political control and national dictatorship would seem unlimited. Its opportunities for widespread sabotage at long range through intentional errors in designs, plans, and specifications with delayed discoveries would be unique and it would be difficult or impossible for laymen to trace the blame, as such tracing would require engineering knowledge which would be union-controlled. Mental sit-down strikes would be hard to controvert.

Any such concentration of power would be autocratic, not democratic. Would it be well or advisable? Perhaps? Each professional engineer must write his own answer.

No. 3. What are the causes of the inception of the unionization idea?

It is rather hard to select any other cause for the inception of unionization among any class except that it is an outgrowth of disgruntlement. The union demand is more pay and shorter hours and absolute power to enforce both. Apparently, any support for this comes, among engineers, if graduates, from those who are disgruntled because they have not achieved high placement immediately, as they may have been led to think was their due upon graduation, not realizing that all their school could give them was the fundamental educational tools of their profession and that years of training were still required for their professional development and qualification. From nongraduates any desire for unionization seems to come from those, many of whom should not be classified as engineers, but who have had a somewhat narrow practical experience along some engineering or technical lines and who, while lacking many of the necessary qualifications, would like to acquire the status, professional, legal, and compensative, of a fully qualified professional engineer without further educational or training effort by themselves, hoping to substitute the union big stick for actual ability to serve.

Really well-qualified or successful professional engineers, whether graduate or not, have not been particularly evident in the desire for unionization and the conclusion would be that the demand for unionization does not originate with them.

No. 4. What are the factors behind the aforementioned causes?

Perhaps leading the various other factors exhilarating the growth of the unionization idea is the reluctance shown by some large industries, some powerful public utilities, and some governmental branches and agencies to grant full and proper recognition to engineering as a profession, and on the other hand the preference employment by them of substandard men as technicians in engineering work who are not licensed or registered or otherwise properly qualified engineers, thus building up a pseudo-engineer element that turns readily toward unionism as a means of financial betterment, and at the same time degrading the quality of their employers' engineering work. There is a growing dangerous, but still small and ineffective, element within industry, calling themselves engineers, posing as engineers, and demanding equality with the genuine engineer through unionism.

The cure for this is evident. Industry, utilities, and government should recognize the professional status of the engineer and accord to those qualified as professional engineers that which is their just due, aid in the expansion and unification of the state registration laws for engineers, and have distinctive lines drawn between their engineers and those others who are merely technicians, specialists, draftsmen, and highly skilled artisans. Failure upon their part in this matter is forcing and will force engineers into unionization against their own desires. The organized opposition, however futile, by controlled engineering associations to state registration and to the recognition of professional status of the engineer is a boomerang that is souring many qualified men, particularly in the electrical field, and some industries may find that their short-sighted policies are developing a more or less undesirable situation within their systems which will rise to plague them later. If one branch, say the electrical engineers, becomes fully organized, it would spread to the whole profession.

No. 5. What will increase and enhance activities toward unionization growth and what will have a retarding effect?

For the first part of this question, increased dissatisfaction by qualified engineers in industry's employ because of nonrecognition of their professional status. Filling engineering departments with specialists, technicians, skilled experts, draftsmen, and miscalling them engineers.

Treading in other ways on the professional pride of their bonafide engineer employees. Failure to recognize the facts of the emergence of the engineer to a high professional status, a development inevitable in view of the rapid advance of engineering science during the last sixty years. All these will cause antagonism and loss of loyalty which are conditions rendering listening to union propaganda easy.

To the second part of the question, "what will have a retarding effect?" Recognition of the engineer as a member of a learned profession. National engineering associations, universities, industry, utilities, and government should all assist him in maintaining his profession intact and unified as a profession by fostering, instead of opposing and attempting to emasculate, standard registration laws for professional engineers in all states, and by differentiating between engineers and nonengineers in their employ. Thus, the engineering profession may be established in a position fairly secure against union propaganda infiltration. The profession is most unlikely to unionize unless forced to by poorly disguised and open antagonism to the professional aspirations of its members.

If his legitimate ambitions are thwarted, the beneficent attitude of the engineer may be changed and he is not unaware of the latent power of his profession and the potency of cooperation and unionism, and he may choose to throw in with the technicians, draftsmen, etc., in unionization as the only course open to hin.

It is to be hoped for the good of the nation, its facilities, its people, and the profession of engineering itself, that the path of professional recognition and unity for the engineer be not made too difficult particularly by those who are the chief beneficiaries of his professional advancement.

HARRY E. HARRIS.[23]

TO THE EDITOR:

James A. Herron's question of organization of engineers for labor unions[24] has invited many comments, most of them to the negative. The writer will join this chorus but would like to inject another note in the struggle between capital and labor. This note is not entirely new, because it has stood several practical tests.

When two factions are at war, the two ways to make peace are: Either one wins and dictates, or they agree on a common ground. The latter is usually the better way. If we had constantly good times, there would be less labor questions to be answered, but when booms change with depressions, many people start to think of reasons and origins of the difficulties. Engineers are not excepted.

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[24] "Unionization of Engineers," by James H. Herron, MECHANICAL ENGINEERING, vol. 61, November, 1939, pp. 778–779 and 822.

Few can clearly grasp the full meaning of terms like overproduction, underconsumption, purchasing power, or the influence of gold or politics on the business cycle. Abstract standards such as a kilowatthour or other new systems of basic values are even less understood.

My suggestion would be to base all our standards of compensation on the much desired capital. Reduce capital to the actual investments and good will, and elevate labor to the same level with no watered stock in either faction. The question of labor unions and capital combines would automatically be solved by such cooperation.

A high-school graduating class was told: The certificate is worth $30,000 in gold. This may be or can be a fundamental truth on a basis for valuation in labor, giving the following tentative setup for capitalization.

Public-school graduate	$20,000
With 4-year apprenticeship	30,000
High-school graduate	30,000
With 4-year apprenticeship	40,000
College graduate	40,000
With apprenticeship	50,000

Experience increase per year as per merit.

Promotions in net worth must be earned. Experience will increase the valuation in a real merit system which may work in both directions. The "slipping" college graduate may be bossed by the ambitious public-school graduate who educates himself and uses his wits, brain, and brawn, just as in our present systems. Each can wage a healthy fight for improved valuation in which physical advantages and health may also play a role. When looking for a job, one shows his valuation chart which may be more valuable and less deceiving than references or experience records, and at least supplement the latter. Rating the ability rather than the title may be healthy especially in the engineering profession.

Company books with 1000 employees and $20,000,000 capital investment may look as follows:

Capital invested	$20,000,000
1000 men at average $40,000 rate	40,000,000
Total capital	$60,000,000

Capital returns may be proportioned to that of labor, never higher. Why should an educated healthy man be worth less than his capital rating when compared with capital? A budget may set the approximate rate of dividend or wages for at least three or six months ahead, paying 80 per cent in regular weekly checks, the adjustment to be made every three months.

If the capital rate is equal to the labor rate, both earning 6 per cent, then the average pay for the men is $2400 per year; at 4 per cent it is $1600. Earnings of over 5 per cent would indicate that more men should be employed, and reserves be laid away for times that may be less favorable.

Capital could not earn 20 per cent unless labor that creates the earnings will also obtain about 20 per cent. Different industries and labor boards may see that labor is distributed so that local earnings are not excessive or not too low.

Such a system would reduce supervision of shops and piecework rates and incentives because each man's valuation would be incentive enough. A board of foremen and labor representatives may set the capital values of each man, without favors, which must be comparative in each industry. Officials rising from the ranks are also valuated, preventing rates of 100 or more times that of a man who may be just as clever if he had the same chance in education, opportunities, and auditions.

Purchasing power is money that is spent, not that invested for more dividends. With a proper security for unemployment and old age, each man can spend most of his earnings without the fear of becoming a charge to the community bringing out the real healthy purchasing power. Steady work would result from this purchasing power. Borrowing and easy-credit systems are the principal reasons for temporary overproduction by advance sales resulting in depressions. A cash basis leaves no room for depressions. There is no need for unemployed men to be supported through relief taxes from the employed. Underprivileged and invalids can be valued and placed for what they are deemed to be worth and make an honest living. Time studies and efficiency investigations would be encouraged and willingly submitted to in industry and public service.

This unification of capital and labor only requires good will and will hurt nothing but watered stock in both factions. It will create its own wage-hour laws and government regulation will not be required, therefore it will be a source of peace and justice.

Executives and managers remain, but the management's problems will be simplified and better understood by the other employees. The employees could prove that working and sanitary conditions in the shops will not deteriorate if labor has to pay its share for improvements and show real democracy.

Werner Lehman.[25]

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[25] South Milwaukee, Wis. Mem. A.S.M.E.

Books Received in Library

Aluminiumguss in Sand und Kokille. By R. Irmann. Second edition. Akademische Verlagsgesellschaft, Leipzig, 1939. Cardboard, 6 × 9 in., 166 pp., illus., diagrams, charts, tables, 8.60 rm. This book gives explicit, practical advice upon the production of sound and permanent-mold aluminum castings. The preparation of casting alloys, melting procedure, casting and molding practice, and the cleaning and heat-treatment of the castings are described.

A.S.T.M. Standards, including Tentative Standards, 1939. 3 volumes. Vol. I, Metals. 1308 pp. Vol. II, Nonmetallic Materials, Constructional. 1217 pp. Vol. III, Nonmetallic Materials, General. 1175 pp. American Society for Testing Materials, Philadelphia, Pa., 1939–1940. Cloth, 6 × 9½ in., illus., diagrams, charts, tables, $8, any one part; $15, any two parts; $22, all three parts. With this issue, a change in the method of publication has been adopted. Hereafter, the standards and tentative standards will be issued collectively, every three years, in one publication divided into three parts: Metals; nonmetallic materials, constructional; and nonmetallic materials, general. Individual parts may be purchased. Supplements will be issued to the parts in the two years between editions. The new arrangement will greatly facilitate reference. Improvements in typography and indexing have also been introduced.

Boiler Operator's Guide. By H. M. Spring, Jr. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1940. Cloth, 6 × 9½ in., 353 pp., illus., diagrams, charts, tables, $3. This practical manual of steam-boiler operation and maintenance is intended as an aid for steam engineers, inspectors, and those preparing to pass license examinations. It explains design problems, then describes the construction and characteristics of all types of steam boilers, and the methods of installing, operating, and maintaining them; 310 questions, with answers, are included typical of those asked on license examinations. The result is a handbook of unusual quality on this subject.

Davison's Rayon and Silk Trades, the Standard Guide, 45th Annual, 1940, Pocket Edition. Davison Publishing Co., Ridgewood, N. J., 1940. Cloth, 5 × 7½ in., 452 pp., illus., maps; $5.50; de luxe office edition, $7.50. This directory of mills, dyers, and finishers in the rayon and silk trades contains both geographical and classified lists, as well as an alphabetical index. A buyers' guide indicates sources for equipment, and the railroads serving the various plants are listed.

Deutsches Museum, Abhandlungen und Berichte, Jg. 11, Heft 1, 1939. Zeit und Zeitmessen, by W. Uhink. V.D.I. Verlag, Berlin, 1939. Paper, 6 × 8 in., 32 pp., illus., diagrams, 90 rm. The various aspects of time and time measurement are briefly covered in this pamphlet. Time units and divisions, zero points for computations, methods of measurement, and uses for very accurate determinations are described and illustrated.

Dictionary of Paper, including Pulps, Boards, Paper Properties, and Related Paper-Making Terms. American Paper and Pulp Association, New York, N. Y., 1940. Cloth, 6 × $9^{1}/_{2}$ in., 365 pp., tables, $5; prepublication price, $4. This dictionary is an ambitious and highly successful attempt to provide the paper industry with an accurate, comprehensive nomenclature. As far as possible, the definitions are given in nontechnical terms which can be understood by those unacquainted with the industry. The book is the work of a committee of the American Paper and Pulp Association, with the cooperation of The Institute of Paper Chemistry.

Electric Transportation. By F. R. Thompson. International Textbook Co., Scranton, Pa., 1940. Cloth, 6 × $9^{1}/_{2}$ in., 427 pp., illus., diagrams, charts, tables, $4. The purpose of this volume is to present methods of applying electrical equipment in passenger and freight transportation. The procedure involves the establishment of the problem, the selection of the general classes of equipment, the function of the individual groups of parts, the ratings and limitations that are commercially practicable, and the operating results. Transportation by city surface cars and buses, subway and elevated systems, and main railways is discussed.

E.Q.A., Engineering Questions and Answers. 2 volumes. Emmott & Co., London and Manchester, England, 1936–1939. Paper, 7 × 10 in., illus., diagrams, charts, tables; Vol. 1, 176 pp., 6s; Vol. 2, 176 pp., 6s. These volumes contain a selection of the questions and answers which have appeared in the *Mechanical World* during the years 1934 to 1938. These questions deal with a great variety of difficulties and problems which have arisen in shops and mines, in construction work, and manufactories. The answers are full and the volumes will be useful for reference.

Élasticité et Photoélasticimétrie. By H. Le Boiteux and R. Boussard, preface by M. P. Langevin. Hermann & Co., Paris, France, 1940. Paper, 7 × 10 in., 361 pp., illus., diagrams, charts, tables, 180 fr. This treatise is the first French work to provide a complete exposition of the photoelastic methods of studying stresses in materials. The first section gives the fundamental mathematical theory of elasticity; the second, the principles of optics involved. Part three discusses photoelastic principles, apparatus, and methods; and part four, the determination of stresses by photoelastic studies.

Engineering Reorganization. By J. J. Gillespie, with a foreword by D. Brown. Pitman Publishing Corporation, New York, N.Y., 1940. Cloth, $5^{1}/_{2}$ × $8^{1}/_{2}$ in., 268 pp., illus., diagrams, charts, tables, $4. This book is written for engineering companies not engaged in continuous or mass production. The general subjects of planning, material and quality control, time study and job analysis, costing, and sales methods are discussed, together with many specific examples and applications to particular shops and departments.

Experimental Aerodynamics. By H. C. Pavian. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1940. Cloth, 6 × $9^{1}/_{2}$ in., 168 pp., illus., diagrams, charts, tables, $2.50. This text contains a simple, concise presentation of the elements of wind-tunnel work, in which stress is laid on its applications in air conditioning, streamlining, etc., as well as in aviation. The work is intended as a text and laboratory handbook in technical schools and colleges. In addition to numerous experiments, brief notes on model building and the construction of small wind tunnels are included.

Fuel Flue Gases, the Application and Interpretation of Gas Analyses and Tests. American Gas Association, New York, 1940. Cloth, $8^{1}/_{2}$ × 11 in., 198 pp., illus., diagrams, charts, tables, $5. This book has been prepared under the auspices of the chemical section of the American Gas Association, as a summary of the manner in which chemical work can be practically and usefully applied to the everyday problems of the gas industry. The first five chapters are devoted to fuel gases and discuss their analysis, physical testing, the application of gas analyses, and the specific constituents of fuel gases. The sixth chapter is on the chemistry of the distribution system and its problems; the seventh considers atmospheres other than those composed of combustion products. The final two chapters, on the gases that result from combustion, discuss furnace atmospheres and flue-gas analysis. Throughout, attention is directed to the application and interpretation of analyses. Numerous bibliographic footnotes are included.

Gas Engine Handbook, Gas Engine Power Committee. American Gas Association, Industrial Gas Section, New York, 1939. Paper, $8^{1}/_{2}$ × 11 in., 58 pp., illus., diagrams, charts, tables, $1. A concise manual on the functioning of gas engines, their selection for various purposes, and their installation. The information is practical, clear, and devoid of unnecessary technicalities. The book is intended primarily for those interested in the sale and promotion of gas engines.

General Physics for Students of Science. By R. B. Lindsay. John Wiley & Sons, Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 534 pp., diagrams, charts, tables, $3.75. This basic introductory textbook for science students treats the customary topics of mechanics, heat, electricity, magnetism, and radiation (which includes acoustics and optics) in a more rigorous, mathematical manner than usual. Many problems, some of considerable difficulty, accompany the various chapters.

Great Britain. Scientific and Industrial Research Department Methods for the Detection of Toxic Gases in Industry. Leaflet No. 8. Phosgene. 7 pp., $0.75. Leaflet No. 9. Arsine. 6 pp., $0.75. Leaflet No. 10. Chlorine. 7 pp., $0.10. Leaflet No. 11. Aniline Vapour. 9 pp., $0.10. His Majesty's Stationery Office, London, 1939. Paper, 6 × 10 in., charts, diagrams, tables. These pamphlets give detailed directions for determining the presence of dangerous gases or fumes in factories. The methods are simple and the directions sufficiently explicit to be used by comparatively unskilled persons.

Heating, Ventilating, Air Conditioning Guide, Vol. 18, 1940. American Society of Heating and Ventilating Engineers, New York, N. Y. Cloth, 6 × 9 in., 1088 pp., illus., diagrams, charts, tables, $5. This annual publication is an admirable summary of the scientific and practical information needed by heating and ventilating engineers, kept up to date by constant revision. The needs of designers and installers of apparatus for heating, ventilating, and air conditioning are fully covered, both for domestic and industrial purposes. In addition to revision where necessary, a new chapter has been added, on unit air conditioners, cooling units, and attic fans. The Guide also contains a manufacturers' section, which lists apparatus and materials, and the membership list of the Society.

Impact Cleaning. By W. A. Rosenberger. Penton Publishing Co., Cleveland, Ohio, 1939. Cloth, 6 × $9^{1}/_{2}$ in., 466 pp., diagrams, charts, tables, $7. The term, "impact cleaning," has been coined as a comprehensive name for those processes which employ an abrasive projected at high velocity. This book provides a practical account of the equipment used in the different methods, the details of the working processes, and their fields of usefulness. A section is devoted to ventilation problems.

Introduction to the Theory of Functions of a Real Variable. By S. Verblunsky. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1939. Cloth, $5^{1}/_{2}$ × 9 in., 169 pp., tables, $4.25. In order to facilitate the progress of the student, the subject is treated as a body of deductions from specified postulates, and the successive topics are considered in logical order. These topics, in order, are number, sets and functions, convergence, continuity and the derivative, elementary functions, primitives, limits and higher derivatives, integrals, and series. There are many examples with proofs.

Kautschuk und verwandte Stoffe, Eigenschaften und Verarbeitung. Edited by S. Boström, K. Lange, H. Schmidt, and P. Stöcklin. Union Deutsche Verlagsgesellschaft, Berlin, Roth & Co., 1940. Cloth, 6 × $9^{1}/_{2}$ in., 534 pp., illus., diagrams, charts, tables, 80 rm. This is a comprehensive, detailed work on the production and manufacture of natural and synthetic rubbers and their products. The forms of natural rubber and the synthetic rubbers, together with the other ingredients of rubber goods, are first discussed. Rubber-working machinery is then treated. Special attention is given to the manufacture of important rubber products, shoes, tires, belting, insulated wire, hard rubber, etc. A section is devoted to the direct working of latex, and another to synthetic-rubber products. Finally, chemical and mechanical testing methods are outlined.

Mechanics Applied to Vibrations and Balancing. by D. L. Thornton. John Wiley & Sons, Inc., New York, N. Y., 1940. Cloth, 6 × 10 in., 529 pp., illus., diagrams, charts, tables, $7.50. The purpose of this book is to present the general theory of vibrations in its various aspects. While written primarily for engineers, it should also be of use to students of physics. The subjects discussed include the balancing of locomotives and engines, the theory of vibrations, the propagation of stress in elastic materials, and vibrations in beams and plates and in rotating shafts and disks. A final chapter gives a general survey of the subject and of its applications to the testing of materials, to ships, bridges, traffic, geophysical surveying, etc.

Metals—How They Behave in Service. By W. J. Diederichs and others. American Society for Metals, Cleveland, Ohio, 1939. Paper, 6 × 9 in., 45 pp., illus., diagrams, charts, tables, $1. This pamphlet contains five lectures delivered during 1936 and 1937 under the auspices of the Philadelphia chapter of the American Society for Metals. The speakers discussed behavior under static loads, repeated loads and impact, and the effects of corrosion and behavior at different temperatures.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. Officers Nominated for Coming Year

Members of the A.S.M.E. Nominating Committee for 1940, O. A. Leutwiler, chairman, A. R. Mumford, secretary, E. R. Fish, D. G. Williams, K. P. Kammer, C. M. Gross, and B. T. McMinn have nominated as directors of the Society for 1940 the following:

Office	Nominee
President	William A. Hanley
Vice-Presidents	Samuel B. Earle Frank H. Prouty Edwin B. Ricketts
Managers	Huber O. Croft Paul B. Eaton George E. Hulse

Biographical sketches of the candidates for office will be published in the August issue of Mechanical Engineering.

A.S.M.E. Inland Empire Section to Be Host at Fall Meeting at Spokane, Wash., Sept. 3–6

THE arrangements for the A.S.M.E. Fall Meeting at Spokane, Washington, are practically complete and the Inland Empire Section is looking forward to the opportunity of acting as host and of showing off the Pacific Northwest at its best. An interesting group of papers is to be presented in sessions sponsored by the Hydraulic, Wood Industries, Fuels, Power, and Management Divisions, and the Heat Transfer Group. The inspection trips stressing wood industries, power developments, mineral industries, and scenic wonders are unique and of general as well as of technical interest. An entertainment program for women is being planned and opportunities to play golf and visit the lakes have been arranged.

The arrangement of the program calls for technical sessions Tuesday, Sept. 3, and Thursday, Sept. 5, leaving Wednesday and Friday open for inspection trips. The trip to Grand Coulee Dam on Wednesday will be preceded by a general talk on the Dam at the banquet on Tuesday evening. Friday is being left open for trips to the lumber mill at Lewiston, the mines of Northern Idaho, the Columbia River Basin Project, or the scenic lakes of the region.

It is planned to have only nontechnical talks at dinners and the banquet held during the convention.

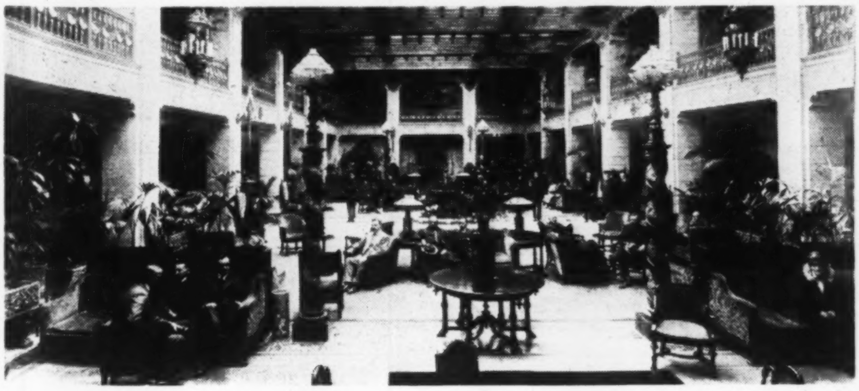
A Day at Grand Coulee Dam

One of the greatest attractions of the meeting will be the day spent at the Grand Coulee Dam. This project with its 300,000 visitors last year is rapidly becoming the major point of tourist interest in the Pacific Northwest. The Dam involving to date an expenditure of approximately $130,000,000 will upon completion be the world's largest masonry structure, exceeding by a wide margin the pyramid of Cheops in Egypt and the Hoover Dam. This fall will be an ideal time for a visit to it as the concrete placement may still be seen in its final stages and the hydraulic machinery will be in the process of installation. At the present time turbine parts are on the ground ready for assembly.

It will also be possible to view the effect of the Dam in producing the largest artificial lake in the world. This lake will be 151 miles long, have a maximum depth of 375 feet, and in one place will be as much as six miles wide. Visitors will find steamer and launch service available and, time permitting, may go up the lake to Kettle Falls, a town 100 miles above the Dam. Arrangements may also be made for an airplane trip out over the Coulee Dam, the Dry Falls, and the Columbia River Basin—this trip being made from Spokane.

Trip to Lewiston

The trip to Lewiston to see the largest pine mill in the world will take place on Friday. This three-hour journey will be made through the rolling Palouse wheat country and will include stopovers at the State College of Washington and the University of Idaho that are located but eight miles apart. In addition to the usual interests associated with such schools, the State College of Washington is operating an experimental plant for the production of magnesium metal that may be of special interest to many. The city of Lewiston, made famous by Lewis and Clark, is located at the junction of the Snake and Clearwater Rivers and is approached by descending the Lewiston grade which offers a chance to view rugged scenery from a height of 1000 feet.



LOBBY OF DAVENPORT HOTEL, SPOKANE, WASH., HEADQUARTERS FOR A.S.M.E. FALL MEETING

Trip to the Mines

For Friday a trip to the mines located in the Idaho Panhandle has also been scheduled. The mines located in and around Wallace and Kellogg are but two hours' drive from Spokane and the ride is over good road through the Coeur d'Alene country. In this vicinity are located such well-known mines as the Sunshine, the Morning, Star, the Bunker Hill and Sullivan, and the Hecla. In this region are also numerous lakes and rivers and forests where logging operations are in progress.

Women's Program

For the women's program, there is planned a trip through the Manito gardens and a luncheon and tea at one of the Spokane country clubs. It has also been arranged to supply guest tickets for those caring to play golf and to make the programs at the banquets of general interest and attractive for the women.

Davenport Hotel to Be Headquarters

Headquarters for the Fall Meeting will be the famous Davenport Hotel, with the most modern of facilities and rooms particularly

SPORTING GO
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Cushing, N. Y.

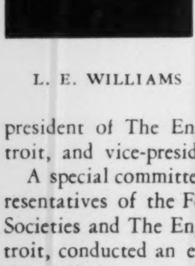
DOWNTOWN STREET SCENE IN SPOKANE, WASH.

suited to convention purposes. Special rates will prevail through the four days for A.S.M.E. members and their guests in attendance.

The city of Spokane is known as the metropolis of the rich inland empire and the gateway to the famous Coulee Dam. It is the largest city between Minneapolis and Seattle and offers to the visitor a magnificent scene of modern architecture. It is picturesquely located at the Falls of the Spokane River—on this river alone there are seven hydroelectric plants with a total installed capacity of 183,000 horsepower. Spokane power operates the mines of the Coeur d'Alene, maintains extensive irrigation projects, and turns the wheels of the city's industries. It flows through the center of the city with falls, 70 feet high, actually in the business district.

Engineering Societies Personnel Service, Inc., to Open Detroit Office

L. E. Williams to Be Manager



L. E. WILLIAMS

TO MEET the greatly increased demand for all types of engineers, especially in the large industrial areas of America, the Engineering Societies Personnel Service, Inc., with offices in New York, Chicago, and San Francisco, has been requested to open a fourth regional office in Detroit, according to a statement made June 15 by James W. Parker, president of The Engineering Society of Detroit, and vice-president A.S.M.E.

A special committee, which consists of representatives of the Four Founder Engineering Societies and The Engineering Society of Detroit, conducted an extensive study and made the preliminary arrangements. The personnel of this committee, which will act as an advisory board to the Detroit office, consists of R. Foulkrod, chairman; J. H. Walker, representing The Engineering Society of Detroit; W. C. Hirn, Michigan Section, A.S.C.E.; F. P. Zimmerli, Detroit Section, A.I.M.E.; C. J. Freund, Detroit Section, A.S.M.E.; and R. E. Greene, Michigan Section, A.I.E.E.

Opening about July 1, the new office will be located in the Hotel Statler until such time as it can move into permanent quarters in the E.S.D. Building, now under construction. L. E. Williams, well-known engineer of Detroit, has joined the staff of the Service and will be manager of the newly established Detroit office. A registered civil and marine engineer in the state of Michigan, he is acquainted with thousands of engineers and executives in the Detroit area, having been president of the E.S.D. and the Michigan Engineering Society. As an engineer, he has designed and built tunnels, bridge foundations, dry docks, marine equipment, and machinery for handling sand and gravel. He was connected in an executive capacity with several companies and has served on technical committees of the A.S.T.M., American Concrete Institute, National Sand and Gravel Association, and other engineering groups.

In his statement telling about the establishment of engineering employment facilities in Detroit with national ties, Mr. Parker said that the thorough study by the special committee showed the need of a local office and that the tie-in with the Engineering Societies Personnel Service, Inc., should be of real service to the engineers in the Detroit area. The committee also felt that a regional office in Detroit would permit personal examination of an applicant's qualifications, personality, and appearance, thus making possible a more efficient and intelligent classification of an application. Furthermore, this plan would also be of great benefit to local employers because of the possibility of obtaining more complete and detailed specifications of their requirements and of making direct referrals more easily.

A notice of the change of name to Engineering Societies Personnel Service, Inc., will be found on page 576 of this issue.

A.S.M.E. Management Division Cooperates in Conferences

THE Management Division of The American Society of Mechanical Engineers in line with a policy of broadening its usefulness to engineering and industry was instrumental in organizing with other organizations two important conferences. In cooperation with the Production Division of the American Management Association and several employer organizations, the Division sponsored a conference on cost reduction, which was held at the Hotel Pennsylvania, New York City, May 22–23. At nine sessions, speakers discussed methods of "cutting costs enough to permit more people to buy more products."

In conjunction with the School of Engineering of George Washington University, the Management Division conducted "The Institute of Management Policy," in Washington, D. C., June 10–11. Devoted to the subject of management consequences of the Federal Wage Hour Acts, the conference presented more than a dozen speakers from the fields of management, labor, education, and government. As was outlined in the opening session by Frederick M. Feiker, member A.S.M.E. and head of the School of Engineering at the University, the object of the institute "is to provide a basis for the better understanding of the principles and practices of federal legislation with special reference to administrative problems between the agencies of the Government and of engineering and industry."

Plans are now being completed by a special committee, L. P. Alford, chairman, for the A.S.M.E. Management Congress which is to be held in New York City in April, 1941.

Iron and Steel Division Name Is Changed to Metals Engineering

IN ORDER to encourage papers and interest in the nonferrous, as well as the ferrous field, particularly brass and aluminum, the Iron and Steel Division requested the Council of the A.S.M.E. to permit its name to be changed to one more descriptive of its functions. At the May 24, 1940, meeting of the Standing Committee on Professional Divisions, it was announced that Council had approved the change and that hereafter the Iron and Steel Division would be known as the Metals Engineering Division.

Actions of A.S.M.E. Executive Committee

On April 30, 1940, just prior to the Spring Meeting, May 1–3, of The American Society of Mechanical Engineers at Worcester, Mass., the Executive Committee of the Council of the Society met with representatives of the Council and standing committees. There were present Warren H. McBryde, president, James W. Parker, Kenneth H. Condit, and Clarke Freeman, of the Executive Committee; Harvey N. Davis, Alfred Iddles, Francis Hodgkinson, J. C. Hunsaker, K. M. Irwin, and Carl L. Bausch, of the Council; Erik Oberg (Meetings and Program); C. B. Peck (Publications); Harte Cooke (Professional Divisions); and J. N. Landis (Local Sections); Walter M. Wilcox and Russell H. Wood, junior observers; and C. E. Davies, secretary. Actions taken by the Executive Committee that are of general interest are summarized as follows:

A telegram from H. H. Morgan, president A.S.T.M., congratulating the A.S.M.E. on its sixtieth anniversary was read and received with appreciation.

National Conference on Engineering Positions

The secretary was appointed an observer to the National Conference on Engineering Positions. This conference is an agency whose formation was recommended by representatives of some of the engineering societies who attended a Joint Conference on Engineering Salaries called by George T. Seabury, secretary, American Society of Civil Engineers. A.S.M.E. representatives who attended the preliminary conference as unofficial observers were R. L. Sackett, H. B. Oatley, and C. E. Davies. Recommendations that A.S.M.E. participate in the permanent conference were made by these representatives and by the Special Committee on the Economic Status of the Engineer. The purpose of the National Conference on Engineering Positions as stated in the scheme of organization is worded as follows: "To formulate a program that will embody classifications of engineering positions and compensation for salaries therein which can be supported by the professional engineering societies, and which will serve alike the interests of the public and the members of the profession."

Cushing, N. Y.

PASSENGER STATION OF SPOKANE AIRPORT

MANITO PARK, SPOKANE, WASH.

Sale of Preprints of A.S.M.E. Papers

Rules regulating the sale of preprints of papers presented at national meetings of the A.S.M.E., recommended by the Committee on Meetings and Program, were approved as follows:

(1) To give free one copy of each preprint available to each person present at a technical session at which the paper is presented.

(2) To charge for preprints (other than for the copies distributed at the sessions), at the following rates:

Members, 10 cents per copy before and after the meeting; 5 cents per copy during the meeting.

Nonmembers, 20 cents per copy before and after the meeting; 5 cents per copy during the meeting.

(3) To continue the policy of presenting gratis to each author 25 copies, 15 to each when there are two coauthors, and 10 to each when there are three or more coauthors.

Standing Committee Recommendations Approved

Changes in national meetings in 1941 as recommended by the Committee on Meetings and Program were approved. The 1941 Spring Meeting will be held in Atlanta, Ga., and the 1941 Semi-Annual Meeting in Kansas City, Mo.

Approval was voted of a recommendation of the Committee on Professional Divisions to change the name of the Iron and Steel Division to Metals Engineering Division. See page 568 of this issue.

Upon recommendation of the Committee on Professional Divisions and the Management Division, the division was authorized to act as cosponsor to the first Institute on Management Policy at the George Washington University, June 10–11, 1940. See page 568 of this issue.

Appointments

The following appointments were reported for record:

Sectional Committee on Standardization of Bolt, Nut, and Rivet Proportions, Arthur M. Houser; Small Tools and Machine-Tool Elements, A. F. Murray; Ball and Roller Bearings, S. M. Weckstein; Standards for Rotating Electrical Machinery, Constantin Rick; Petroleum Products and Lubricants, Robert G. N. Evans.

Power Test Code Committees: No. 10, Centrifugal and Turbo-Compressors and Blowers, Subcommittee on Fans, Theodore Baumeister, Jr.; No. 20, Speed, Temperature, and Pressure Responsive Governors, R. J. Caughey, Harte Cooke, W. L. H. Doyle, S. Logan Kerr, A. F. Schwendner, R. B. Smith, and C. R. Soderberg.

Research Special Committee on Critical Pressure Steam Boilers, E. C. Petrie.

Student Conferences, 1940: Group I, Worcester, Mass., May 3–4, J. C. Hunsaker; Group II, Newark, N. J., April 29–30, Francis Hodgkinson; Group III, College Park, Md., April 25–26, C. E. Davies; Group IV, Birmingham, Ala., April 1–2, J. W. Eshelman; Group V, Chicago, Ill., April 15–16, L. W. Wallace; Group VI, Kansas City, Mo., April 26–27, Linn Helander; Group VII, Lubbock, Tex., April 19–20, W. R. Woolrich; Group VIII, Moscow, Idaho, April 28–May 1, W. Lyle Dudley; Group IX, Salt Lake City, Utah, April 19–20, F. H. Prouty; Group X, Santa Clara, Calif., March 29–30, W. H. McBryde.

Engineers' Council for Professional Development, A. R. Stevenson, Jr. (reappointed, three years).

Washington Award Commission, C. B. Nolte (reappointed, two years).

Washington Award Presentation, Chicago, Ill., April 15, W. L. Abbott, representative.

Dr. Timoshenko Is Elected to National Academy Sciences

At the annual meeting of the National Academy of Sciences held in Washington, D. C., April 22–24, under the presidency of Dr. Frank B. Jewett, among the new members elected was Dr. Stephen Timoshenko, fellow A.S.M.E. and professor at Stanford University. Dr. J. C. Hunsaker, vice-president A.S.M.E., was elected to succeed Dr. Arthur Keith as treasurer for a term of four years.

PRESENT AT THE AERONAUTICS LUNCHEON

(Left to right: T. P. Wright, vice-president in charge of engineering, Curtiss-Wright Corp.; E. W. Edwards, British Purchasing Commission, representing The Institution of Mechanical Engineers; Carl Dolan; Capt. Frank Courtney, speaker; E. A. Sperry, Jr.; and Prof. Kenneth Davidson, Stevens Institute of Technology.)

Flying Boats Discussed at A.S.M.E. Aeronautics Luncheon

Paper by A. Gouge Presented by Capt. Frank Courtney

AT A luncheon held at the Engineers' Club, New York, N. Y., on Tuesday, May 21, 1940, under the auspices of the Aeronautic Division of The American Society of Mechanical Engineers opportunity was afforded for the presentation and discussion of a paper, "Transatlantic Air Transport With Particular Reference to Flying Boats," by A. Gouge, general manager, Short Brothers (Rochester & Bedford) Ltd., of Rochester, England.

The paper was one of four on transportation problems that had been contributed by The Institution of Mechanical Engineers (Great Britain) for the Fall Meeting of the A.S.M.E. and the British American Engineering Congress, scheduled for Sept. 4–8, 1939, at New York, N. Y., but postponed because of the outbreak of war in Europe. Abstracts of the four papers appeared in the December, 1939, issue of MECHANICAL ENGINEERING, pages 876–884, and in full in the November, 1939, issue of the Proceedings of The Institution of Mechanical Engineers. Discussion of the paper by Mr. Gouge originating in England was published in the December, 1939, issue of the Proceedings I.M.E., pages 83–85, and was summarized in the June, 1940, issue of MECHANICAL ENGINEERING, pages 477 and 478.

Carl Dolan Presides

About thirty were present at the luncheon in New York, and in the absence of Mr. Gouge, the paper was excellently summarized by Capt. Frank Courtney, technical representative, Saunders Roe Flying Boat Manufacturers, New York. Carl Dolan, of the Intercontinent Corporation, New York, N. Y., chairman of the A.S.M.E. Aeronautic Division, presided.

A. Klemin Questions Flaps, Porpoising

Discussion of the paper centered around questions which Captain Courtney and others undertook to answer.

Prof. Alexander Klemin, of New York University, member A.S.M.E., inquired about British experience in the use of flaps. With the high wing loadings employed, it was his opinion that flaps and other high-lift devices would be used. Such devices act, as a rule, more beneficially at landing than at take-off. With higher relative drag in the water, however, it might prove advantageous to use the flap at take-off.

Captain Courtney replied that the use of flaps on a flying boat at take-off should be given more study. Their use on a landplane added too much to the total drag, and in a flying boat, while it added to the wing drag, it relieved the water drag. It was British practice to set the flaps at 10 deg for take-off, but lately settings from 8 to 14 deg had been used with no particularly harmful results. However, setting the flaps at too great an angle has tended to start "porpoising" of the ship, a dangerous and possibly destructive bumping action on the water surface, hydraulically analogous to wing flutter. Raymond B. Quick, technical director, U. S. Aviation Insurance Group, said that Pan American Airways did not gradually lower flaps as the ships gathered speed after take-off but preset them.

In reply to a question by Professor Klemin regarding the use of stainless steel in the construction of large flying boats, Captain Courtney recounted the experience of Mr. Gouge with flying-boat hulls made of this material up to the water line. There was no structural advantage in making the entire hull of stainless steel. Difficulties in construction were encountered and the junction of the stainless steel with the duralumin caused so much trouble that this method of construction was abandoned.

Reverting to the subject of porpoising, Professor Klemin stated that he had been working on the problem in connection with the Courtney amphibian and asked if any information were available on the effects of increased size and loading on the tendency to porpoise.

Captain Courtney replied that the subject of porpoising demanded an entirely new line of study. It was a hydrodynamic problem, and in so far as flying boats were concerned the amount of development work that had been done with it was very small. As compared with the status of aerodynamic research, the situation with respect to hydrodynamic studies of flying boats was as though there existed 10 small and but one large wind tunnel. In his opinion, increased size had no effect on the tendency to porpoise. He had seen small ships as well as large ones break up as a result of porpoising. It was his belief also that neither increased wing loading or hull loading was a cause of porpoising.

In reply to Professor Klemin's question relating to the status in England of the compression-ignition engine for airplane use Captain Courtney asserted that development had ceased, so far as he knew. Mr. Dolan commented on the development of the Guiberson Diesel engine in this country.

T. P. Wright Discusses Engines and Assisted Take-Off

T. P. Wright, Curtiss-Wright Corporation, New York, N. Y., shared Mr. Gouge's remarks in the paper that deplored the fact that the Diesel engine had not been given greater consideration, particularly for planes engaging in long-range flights. Anything that reduced fuel consumption was important. The Diesel engine weighed 1.6 lb per hp as against 1.2 lb per hp for the gasoline engine. The present Diesel engine started to gain on the present gasoline engine after about 1500 miles of flight. It would add to the cruising range and hence would offer a distinct advantage in this particular over the gasoline engine. It was to be hoped that the United States would take up the development of the Diesel engine for aircraft, for, although thousands of dollars had been spent on development of the gasoline engine, practically nothing had been spent on the aircraft Diesel. The reason for this retarded development was that heretofore range had not been as important as it is at the present time.

Mr. Wright went on to say that the assisted take-off might become important in transatlantic flying. The objectives were to permit satisfactory take-offs with outside help and to make possible the use of increased wing loadings. Assisted take-offs would not pay in this country where the longest "hops" are in the order of 800 to 900 miles.

It was his opinion that there would be an improvement in the relative performance of the landplane in respect to the flying boat. At present the wing loading of the flying boat was 49.4 lb per sq ft as against 36 lb per sq ft for the landplane. However, if the wing loading of the landplane were increased to 50 lb per sq ft, the performance would increase. The ideal condition, he said, was found when parasite drag and wing drag were equal, at about 60 lb per sq ft. Assisted take-offs, like those of the Short-Mayo composite aircraft or the catapulting used by the Germans in their transatlantic flights, would improve the case for the landplane. He was becoming more and more convinced that the landplane would be used in transoceanic flying. In severe weather the flying boat would not stand up on the surface of the ocean in any event, and the danger involved in forced landings was becoming so small that landplanes could be used in flying over the water.

More Powerful Engines in Future

As to horsepower per engine, it was now possible to secure engines of 2200 hp. Within a year, he predicted, this would be increased to 2500 hp; in fact the limit of power per unit had not been reached. It would be necessary, however, to use some type of hollow-bladed propeller, so that propeller weight would not be a limiting factor with increase of power and altitude. Increase in propeller diameter might be met by using dual-rotation propellers.

Flying at high altitude, he said, had the advantages of greater performance, better weather conditions, and more comfort for passengers. It was his opinion that the public will demand "pressurized" cabins. He thought that the use of slotted flaps could be developed to secure definitely better take-off as had been demonstrated in tests. If the flaps would be used in a normal position for a greater part of the run and then be put in a more economical position, a decided advantage would be found at take-off.

Landing on the Ocean

To a question by Elmer A. Sperry, Jr., vice-president, Sperry Products, Inc., Hoboken, N. J., member A.S.M.E., regarding the forced landing of flying boats on the ocean in rough weather, Captain Courtney replied that it should be possible to design and build a flying boat that could come down in any kind of water with safety. Take-off was another matter; a flying boat could not be expected to take-off from the surface of the ocean in rough weather.

The necessity for assisted take-offs, said Captain Courtney, was decreasing as the take-off horsepower was increasing. An airplane powerful enough to fly long ocean ranges safely would probably have to be able to fly on half its cruising horsepower. For the take-off, then, there would be available the full cruising horsepower plus a further amount permissible to use under take-off conditions.

Engineers Start Mobilizing for National Defense

Census of 115,000 Engineers and Architects

MOBILIZATION of the engineering and architectural professions for national defense is underway now with the preparation by their professional organizations of a nation-wide census of 115,000 engineers and architects skilled in the design and supervision of all types of construction needed in case of national emergency, according to a joint statement made in June by John P. Hogan, member A.S.M.E., and president of the American Society of Civil Engineers, and Stephen F. Voorhees, member A.S.M.E., representing the American Institute of Architects.

The listing and classification of 100,000 engineers at A.S.C.E. Headquarters, 29 West 39th Street, New York City, and of 15,000 architects at the home of the A.I.A., The Octagon, Washington, D. C., will be carried out in three steps. Each man will be selected as to his skill in the design and supervision of construction of airports, water supply and purification plants, sewage and industrial-waste disposal systems, roads, tunnels, enlargement of industrial plants, port developments, and cantonments with barracks and the necessary mechanical, refrigerating, heating, and ventilating accessories.

Cooperating with the A.S.C.E. in this national movement are the A.I.M.E., A.S.M.E., A.I.E.E., A.I.C.E., A.S.H.&V.E., A.S.R.E., American Institute of Consulting Engineers, American Society of Military Engineers, and the National Society of Professional Engineers.

The first step of the census, just started, is the listing of engineering and architectural firms, partnerships, and individuals in private practice. This is being accomplished by the cooperating national engineering and architectural organizations through special committees in each of their local sections and chapters, which are located in almost every city of the nation and, thus, in a position to provide nearly one hundred per cent coverage. The second step will consist in indexing and classifying each firm or individual according to qualifications so as to permit of ready selection of those best fitted to undertake in any part of the country whatever type of construction would be necessary in the interests of national defense. The final step will be similar to the first two in all details except that, instead of firms, engineers, architects, draftsmen, surveyors, and specialists who may be available will be listed and classified.

In the preparation of the latter list, the special committees will observe the fundamental principle of avoiding the dislocation of those engineers or architects now engaged in industry, in utilities, and in governmental services. This is necessary so that these existing organizations may not be crippled in performing their regular functions by the loss of men valuable to them and who will be essential in any necessary expansions of their functions in case of national emergency.

Franklin Institute Honors Two A.S.M.E. Members

AT special exercises held in Philadelphia, Pa., May 15, The Franklin Institute honored 17 leaders in pure and applied science with medal awards and certificates. Among those honored were Maxwell M. Upson, member A.S.M.E., and president of the Raymond Concrete Pile Co., who received the Edward Longstreth Medal, and William E. Woodard, member A.S.M.E., and vice-president, Lima Locomotive Works, who was given the George R. Henderson Medal.

M. B. Richardson Honored at Luncheon by A.S.M.E. Railroad Division

M. B. RICHARDSON, member A.S.M.E., was honored at a special luncheon tendered to him at the Engineers' Club, New York City, May 23, 1940, by the officers and his associates on the Railroad Division. Presiding at the affair was James Partington, chairman of the Railroad Division in 1926, who presented to Mr. Richardson a framed certificate "in recognition of his loyal and effective service as secretary of the Railroad Division of The American Society of Mechanical Engineers from 1925 through 1939." Included among those present were H. B. Oatley, William Elmer, Eliot Sumner, C. B. Peck, A. I. Lipetz, W. M. Sheehan, Harte Cooke, chairman of the Standing Committee on Professional Divisions, and C. L. Combes, present secretary of the Division.

AMONG THOSE PRESENT AT RICHARDSON TESTIMONIAL LUNCHEON

(Left to right: C. B. Peck, C. L. Combes, M. B. Richardson, guest of honor, William Elmer, James Partington, H. B. Oatley, W. M. Sheehan, Eliot Sumner, A. I. Lipetz, and Harte Cooke.)

(The candid camera "fix-it" group shown trying to lure some of the guests out for a picture: Left to right, C. N. Paxton, with camera; S. S. Smith, A. J. Kerr, and F. E. Richardson.)

(Posing for a "front-view picture" when snapped from the side are: Left to right, W. J. Overton, W. H. Carson, H. S. Bean, and E. E. Ambrosius.)

CANDID CAMERA SHOTS TAKEN ON THE STEPS OF THE COLLEGE OF ENGINEERING BUILDING DURING THE A.S.M.E. PETROLEUM DIVISION MEETING, WHICH WAS HELD AT THE UNIVERSITY OF OKLAHOMA, NORMAN, OKLAHOMA, APRIL 12 AND 13

Instruments and Apparatus, Part 8, Measurement of Indicated Horsepower

Preliminary Draft of Instruments and Apparatus Section on Measurement of Indicated Horsepower Completed

THE draft of Part 8, Measurement of Indicated Horsepower, is completed and the A.S.M.E. Power Test Codes Committee on Instruments and Apparatus welcomes criticism or comment on it by members of the Society and others interested. Copies may be obtained by addressing the Committee, A.S.M.E. Headquarters.

The Committee in charge of this part of the Power Test Codes activity consists of W. A. Carter, chairman, C. M. Allen, W. C. Andrae, E. G. Bailey, H. S. Bean, L. J. Briggs, J. D. Davis, K. J. DeJuhasz, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. W. Johnson, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, W. A. Sloan, R. B. Smith, and I. M. Stein.

Part 8 includes sections on types of indicators, construction, testing and calibration, installation, operation, accuracy, and evaluation of diagrams.

The engine indicator is a recording pressure gage with the aid of which rapidly varying pressures can be recorded as a function of another variable, such as piston travel, crank angle, or time. In a broader sense all such charts are called indicator diagrams; and in a restricted sense the indicator diagram means a chart of pressures inside of a cylinder of an engine or machine drawn on the piston-travel basis. For a complete working cycle, the indicator diagram is a closed curve the area of which is a measure of the work done during one cycle, and the mean height, interpreted in terms of the pressure scale, represents the indicated mean pressure.

The indicator diagram is useful not only for the determination of the indicated mean pressure but also for judging the engine characteristics, such as the instantaneous fluid pressures, and faults in the engine. In connection with the knowledge of the brake horsepower as determined by the brake dynamometer, the indicator diagram is used for the determination of mechanical efficiency and of power loss due to friction.

A.S.M.E. Calendar

of Coming Meetings

September 3–6, 1940

Fall Meeting
Hotel Davenport
Spokane, Wash.

November 7–9, 1940

Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Hotel Tutwiler
Birmingham, Ala.

December 2–5, 1940

Annual Meeting
Hotel Astor
New York, N. Y.

(For coming meetings of other organizations see page 22 of the advertising section of this issue)

Structural Steel Welding Research Committee Formed

FORMATION of a Structural Steel Welding Research Committee to study problems of design and fabrication in the building field was recently announced by the Engineering Foundation, research organization of the A.S.M.E. and the other national engineering societies. Leon S. Moisseiff, New York consulting engineer, and designer of the George Washington and Triboro Bridges in New York, and the Golden Gate and San Francisco–Oakland Bay Bridges, has been chosen chairman. Other members are F. H. Frankland, Jonathan Jones, C. H. Goodrich, A. S. Low, C. A. Trexel, La Motte Grover, Bruce Johnston, H. W. Lawson, and F. H. Dill.

The program includes the establishment of research fellowships in American universities. The first fellowship goes to Lehigh University for a two-year period and carries with it an annual stipend of $1100. Other fellowships will be established as soon as the Committee maps a complete program of research projects. The investigations at Lehigh will be directed toward developing a satisfactory design procedure for beam-to-girder and beam-to-column connections for all kinds of welded building construction.

The work of the Committee, in general, will be to secure basic data which will enable fabricators to apply welding in building with greater safety and with greater economy. By obtaining full information on the effects of varying loads on all classifications of welded connections, the Committee hopes to perform a service for building engineers and aid them in setting up different formulas which will be applicable in each type of construction. At present there is a wide diversity of opinion regarding the best designs for various welded connections.

Correction to

A.S.M.E. Power Test Code for Displacement Compressors, Vacuum Pumps, and Blowers

THE attention of the A.S.M.E. Committee on Power Test Codes has been called to a typographical error in the 1939 edition of the Test Code for Displacement Compressors, Vacuum Pumps, and Blowers. The formula printed in the first column of page 22, twentieth line, should read:

$$w = 59.22\, CD_2{}^2p_2 \sqrt{\frac{\rho_1}{p_1}}\, \sqrt{X(X+1)}$$

Those who have copies of this code in their files are requested to make the necessary corrections.

Akron-Canton Section Completes Successful 1939–40 Program

UNDER the able chairmanship of A. D. MacLachlan, the Akron-Canton Section finished a year of fine programs with the meeting on May 23 at which Dr. William E. Wickenden, president of Case School of Applied Science, spoke on the subject of "Engineering Education and Vocational Guidance." Other excellent speakers during the year just closed included D. R. Means, technical director of Columbia Chemical Division, Pittsburgh Plate Glass Co.; Walter P. Schmitter, chief engineer, Falk Corporation; Prof. J. Ormondroyd, University of Michigan; W. B. Hoey; Bertrand Goldberg, architect; Wilson D. Hunter, aeronautical engineer, B. F. Goodrich Co.; and J. L. Foy, United Airlines.

C.E.S. Awards Honorary Membership to J. H. Herron

AT a dinner celebrating the sixtieth anniversary of the Cleveland Engineering Society, held May 14, an honorary membership was presented to James H. Herron, past-president A.S.M.E., by George R. Canning, the president of C.E.S. At the same time it was announced that the society had just purchased a building on 19th Street, just north of Carnegie Avenue, as permanent headquarters. Prior to occupation, the entire building will be remodeled at a cost of $50,000. Some of the facilities to be incorporated in the new building are a library, offices, lounge, dining room, and assembly room, card room, billiard room, bowling alleys, and storage space. Adjacent to the building, will be a parking lot.

Pittsburgh Celebrates Society Anniversary at All-Day Meeting

PITTSBURGH Section did not celebrate the sixtieth anniversary of the A.S.M.E. on March 28, as was stated in the June issue of Mechanical Engineering, but on April 23 with an all-day meeting featuring six simultaneous technical sessions and a general luncheon, and a total attendance of more than 750 for the meeting. Sessions were well-attended as shown by the following figures: Hydraulics, 70; transportation, 100; management, 70; power, 150; plastics and machining of metals, 60; and oil industry, 40. The general luncheon drew more than 250. Looking at these results, the Executive Committee of the Section and the Meeting Committee should feel well-repaid for their efforts in promoting this first annual affair which promises to become a fixture on future Pittsburgh programs.

San Francisco Section Plans Threefold Affair in July

CHAIRMAN H. G. Raitt of the San Francisco Section announces plans for a banquet to be held on July 11 at the St. Francis Yacht Club. The affair will celebrate the sixtieth anniversary of the A.S.M.E. as well as the thirtieth anniversary of the Section, and give members an opportunity to honor a fellow local member, Warren H. McBryde, President A.S.M.E. Dr. William F. Durand, past-president A.S.M.E., will be toastmaster. He will introduce President McBryde, who will speak of the Society and its future, and Lieut.-Col. Charles F. Wieland, who, as representative of the charter members of the Section, will do some reminiscing. All members and their friends are invited.

Flow Nozzles Available From Fluid Meters Committee

ENGINEERING schools and research laboratories are being offered an opportunity by the A.S.M.E. Special Research Committee on Fluid Meters to purchase at a substantial saving some of the flow nozzles used in the Committee's research work. The nozzles offered for sale together with their asking prices include: Five of low diameter ratio for 2-in. pipe, $40 each; three for 4-in. pipe, $50 each; and ten for 8-in. pipe, $60 each. Money received from the sale will be used to continue the important research work of the Committee.

Nozzles may be purchased singly or in groups. Further information, including dimensions, make, and other specifications, may be obtained from H. S. Bean, A.S.M.E. Special Research Committee on Fluid Meters, National Bureau of Standards, Washington, D. C.

Annual Meeting of Industrial Research Institute

INDUSTRIAL research authorities and deans of engineering of American universities gathered in Cincinnati, Ohio, on April 26 and 27, for the two-day annual meeting of the Industrial Research Institute, affiliated with the National Research Council and composed of industrial concerns maintaining research laboratories. During the meeting, the various new officers of the Institute formally assumed office. H. Earl Hoover, member A.S.M.E., took over the chairmanship of the executive committee; L. W. Wallace, past vice-president A.S.M.E., assumed the vice-chairmanship; and C. G. Worthington, member A.S.M.E., was appointed secretary.

The program consisted of a tour of the research laboratories and plant of the Procter & Gamble Research Laboratory, Friday morning, April 26; panel discussion in the afternoon on how to make relations between industry and universities in research more effective; and a session on Saturday morning at which important problems of research administration were discussed. Speakers included Edward L. Moreland, member A.S.M.E., and Alex D. Bailey, past vice-president A.S.M.E.

Contemporary American Industrial-Art Exhibit

AN exhibition of contemporary American industrial art is being shown until Sept. 15 at the Metropolitan Museum of Art in New York City. The director of the Museum has extended a special invitation to A.S.M.E. members to visit the Museum during the showing.

FOLLOWING A LUNCHEON AT THE ALDEN HYDRAULIC LABORATORY, WORCESTER POLYTECHNIC INSTITUTE, DURING THE 1940 SPRING MEETING, WORCESTER, MASS., MAY 1–3, PROF. C. M. ALLEN (FRONT ROW, SECOND FROM LEFT), THE HOST AT THE LUNCHEON, ASSEMBLED HIS 85 GUESTS ON THE LAWN FOR A PHOTOGRAPH

American Engineering Council

Presents

The News From Washington and Elsewhere

U. S. Rushes $5,000,000,000 Defense Program

GERMANY'S startling successes with her new kind of mechanized warfare has during the last month awakened the United States to one of its periodic realizations that its defenses are entirely inadequate, with the result that rush legislation is currently being passed to provide nearly $5,000,000,000 to expand the personnel, equipment, and facilities of the Army and Navy, and the civil-production facilities necessary to accomplish this task.

The complexities and ramifications of the proposed program are too numerous to be presented here in detail. Among the more significant items are the procurement of full equipment for an army of 1,000,000 men, as compared with a present strength of 230,000; major increases in the number of vessels and personnel of the Navy; and expansion of the air forces. In addition, it is desired to step up facilities for aircraft manufacture to a potential capacity of 50,000 planes per year, as compared with present estimates of 12,000, and to train large numbers of pilots and mechanics.

Included in the Army equipment orders will be large quantities of mechanized units, including tanks, trucks, anti-aircraft and anti-tank guns, fire-control equipment, and similar matériel. Also planned are many new air bases, training stations, and other facilities to care for the increases in personnel and equipment.

A program on so large a scale, requiring the adjustment of private industry to many entirely new products, is sure to have innumerable repercussions. In some lines of industry these will be minor, while in others large problems will arise. Perhaps the three fields most directly affected are the aviation, shipbuilding, and machine-tool industries, already strained to capacity and now facing the need to step up production even more. All three face the immediate necessity of greatly expanding plant capacity and personnel.

Consideration is being given to converting some of the surplus automobile manufacturing capacity to airplane motors. A shortage of tool- and diemakers is anticipated and if it develops the auto manufacturers may be asked to forego their usual annual practice of announcing new models for 1942 (1941 model changes are already well advanced and will not be interfered with). Glenn L. Martin estimates that it now requires from 350 to 400 man-hours to produce a small plane, and the amazing total of 14,000 man-hours to turn out a large bomber, as compared with 218 hours for the standard low-priced motor car. Studies are being made to adopt more mass-production methods and cut down this labor requirement.

Pan-American Industrial Possibilities Studied

FORMATION of an international commission to work toward closer economic collaboration among nations in the Western Hemisphere has been completed, and the first meeting was held in Washington early in June. Its purpose, working through committees of technical experts in each of the countries, is to survey the natural resources available and to point out where, in its opinion, opportunities exist for the investment of capital and the development of new industries with reasonable security for the investor.

Particular attention will be given to the promotion of lines for which there are available markets within the hemisphere, and it is hoped in this way to develop supplementary sources of strategic materials for which the countries concerned are now dependent upon areas of supply subject to interruption in war time. It is pointed out, for example, that Bolivia has large tin deposits and Brazil has already started to promote the production of rubber. Both of these commodities are now furnished to American markets predominantly by Asiatic suppliers.

Men and Positions Available

Send inquiries to New York Office of
Engineering Societies Personnel Service, Inc.

29 W. 39th St.
New York, N. Y.

211 West Wacker Drive
Chicago, Ill.

57 Post Street
San Francisco, Calif.

Hotel Statler
Detroit, Mich.

MEN AVAILABLE[1]

Management Executive, 31, B.S. Three years' graduate studies; nine years' diversified experience: Factory management, production, methods, costs, design, personnel, tabulating, office, marketing analysis. Employed production manager large nationally known corporation. Me-482.

B.M.E., 26, single, marine license. Machine-shop, turbo-electric, reciprocating (steam), and refrigeration operating experience. One year marine piping drafting. Now employed. Will travel for production or maintenance work. Me-483.

June Graduate Mechanical Engineer, 23, single. Ambitious, graduate of Catholic University and Baltimore Polytechnic Institute. Desires opportunity for experience leading to permanent position with Eastern firm. Me-484.

Mechanical and Ordnance Engineer experienced in design, construction, inspection, and testing of machine, automatic, semiautomatic, and rapid-fire guns, sights, mounts, field carriages, ammunition, special machinery and tools, jigs, and fixtures for manufacture. Me-485.

Mechanical Engineer, graduate, 25, single. Experience in design, operation, and management of plant manufacturing powdered metal; also in purchasing. Now employed, prefers position in East, preferably in machine design. Me-486.

Executive, mechanical engineer, under 40. Seventeen years with large corporation assisting chief executive by office management, staff contacts, trade-organization contacts, correspondence, interviews, supervision of subsidiaries, accounting and income tax, special reports and investigations where initiative and adaptability count. Married, perfect health. Me-487-415-Chicago.

Mechanical and Industrial Engineer, 40, graduate in both mechanical engineering and advertising. Extensive experience in production, experimental development, and wholesale distribution of appliances and industrial equipment. Desires responsible executive position. Me-488-320-Chicago.

Mechanical, registered professional engineer, '35 Georgia Tech Co-op graduate. One year drafting. Two years supervising erection, planning, and making erection drawings of semiheavy machinery. Two years designing semiheavy machinery. Me-489.

Certified Public Accountant, New York; industrial engineer, 33. Last ten years controller large manufacturing company. Capable executive. Standard costs, budgets, factory and office systems, time studies, taxes. Me-490.

Mechanical Engineer, 24, B.S. 1939. Air-conditioning and refrigeration major. Desires opportunity for experience leading to responsible position in mechanical-engineering field. Now employed. Available on two weeks' notice. Me-491.

Mechanical Graduate, 27, N. C. State 1936, single. Experience in power-plant operation, construction, and maintenance. Desires steam- or Diesel-plant operation and maintenance. Will go to foreign country. Now employed. Me-492.

Executive Assistant fitted by experience and training for industrial direction; coordination of departments; special investigations; invasion of new markets for present products or new products needed on account war-defense activities. Me-493.

Maintenance Engineer, A.S.M.E., University graduate, 40. Now employed. Fif-

(*A.S.M.E. News continued on page 576*)

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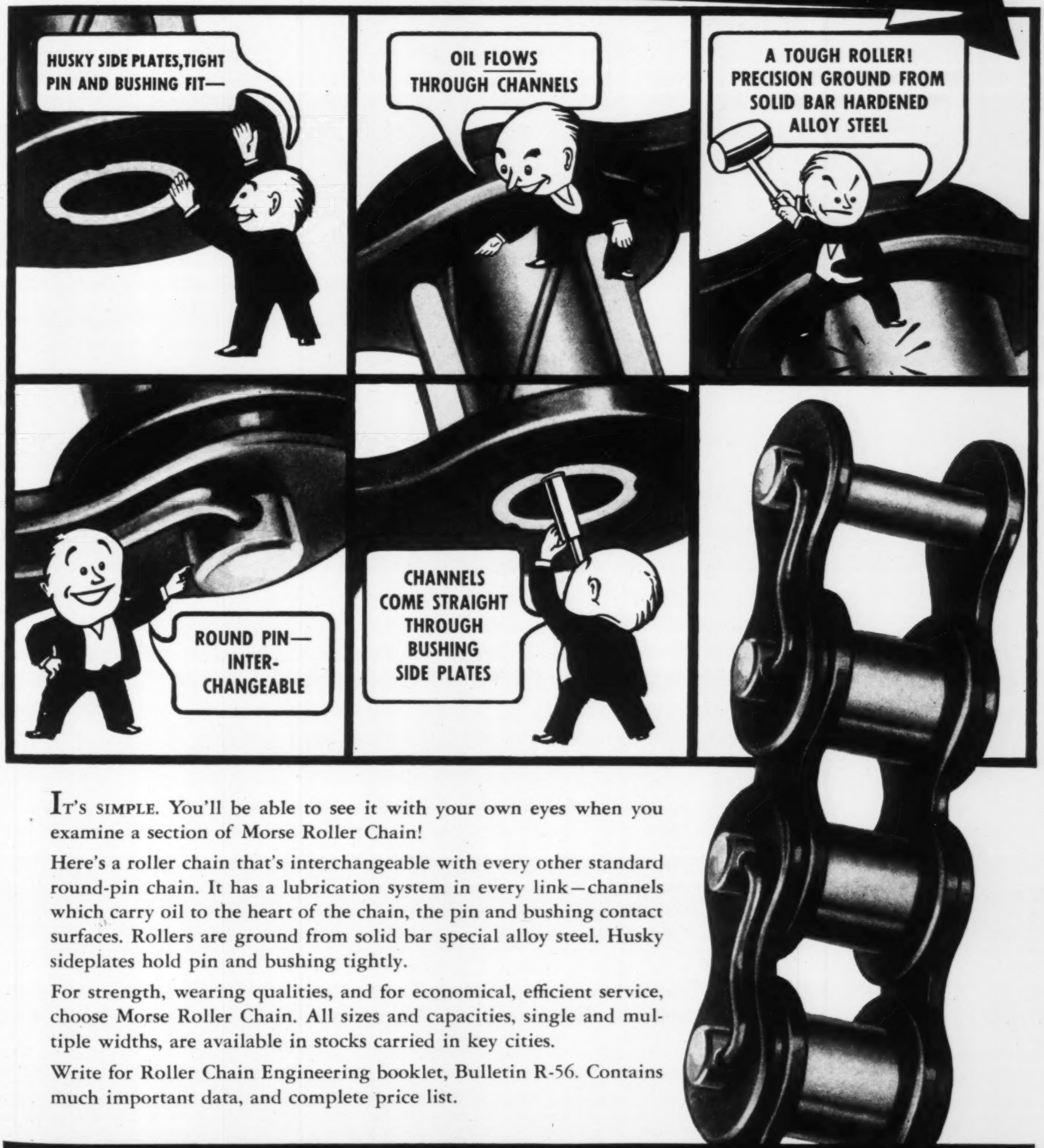
[1] All men listed hold some form of A.S.M.E. membership. Where no city is shown after name, man may be reached through New York office.

Let the Morse Man Show You Why MORSE ROLLER CHAINS Are Better!


HUSKY SIDE PLATES,TIGHT PIN AND BUSHING FIT—
OIL FLOWS THROUGH CHANNELS
A TOUGH ROLLER! PRECISION GROUND FROM SOLID BAR HARDENED ALLOY STEEL
ROUND PIN—INTERCHANGEABLE
CHANNELS COME STRAIGHT THROUGH BUSHING SIDE PLATES

It's simple. You'll be able to see it with your own eyes when you examine a section of Morse Roller Chain!

Here's a roller chain that's interchangeable with every other standard round-pin chain. It has a lubrication system in every link—channels which carry oil to the heart of the chain, the pin and bushing contact surfaces. Rollers are ground from solid bar special alloy steel. Husky sideplates hold pin and bushing tightly.

For strength, wearing qualities, and for economical, efficient service, choose Morse Roller Chain. All sizes and capacities, single and multiple widths, are available in stocks carried in key cities.

Write for Roller Chain Engineering booklet, Bulletin R-56. Contains much important data, and complete price list.

SILENT CHAINS ROLLER CHAINS FLEXIBLE COUPLINGS KELPO CLUTCHES

MORSE *positive* DRIVES

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

Engineering Societies Personnel Service, Inc., Is Now the Name

TO SATISFY certain legal requirements of the several states in which it operates, the employment service of the Four Founder Engineering Societies has been incorporated in New York State and its name changed to Engineering Societies Personnel Service, Inc. Over a period of 17 years, the Service through its offices in New York, Chicago, and San Francisco has placed more than 20,000 engineers in private industry and, in the period of 1930 to 1939, more than 10,000 on WPA and other governmental projects.

At the first meeting of the corporation, held in the Engineering Societies Building in New York, Monday, June 10, plans were made to extend the operations of the Service to a greater degree. George T. Seabury, secretary A.S.C.E., was elected president; C. E. Davies, secretary, A.S.M.E., vice-president; Otis Hovey, treasurer; and A. H. Meyer, secretary.

It was announced that the present staff of the Service will continue in their present positions with the corporation. Members of the staff include Walter V. Brown, manager; Thomas Wilson, manager, Chicago; and Newton D. Cook, manager, San Francisco.

teen years' varied experience including institutional maintenance and development, general construction, and mechanical-electrical design. Mechanically inclined, practical, cooperative supervisor. Interested in position with economic, professional advancement. Me-494.

Mechanical Engineer, 31, single. Experience includes mathematics teaching, process-equipment development, postgraduate study, cost analysis, inspection, and sales. Now employed. Seeking sales or plant control work. Me-495.

Mechanical Engineer, 1939 graduate, B.S., 23. Realizes college training only theoretical, therefore willing to get into overalls to learn actual facts. Likes responsibility. Interested in heat-power engineering. Me-496.

Chief Engineer, technical graduate with worth-while experience in plant layouts and engineering, equipment design and development, construction and power, maintenance and drafting force supervision, particularly in chemical and food industries. Me-497.

Ordnance Manufacturing Executive, large-scale production of 5-in. to 16-in. shells, submarine torpedoes, launching tubes, and mines. Immediately available for organization or direction of production. Me-498.

POSITIONS AVAILABLE

Engineer, 35–40, with foundry experience; mechanical, chemical, or metallurgical graduate preferred; for company manufacturing gray-iron castings and applying of dry-process enamel to smooth gray-iron casting. Foundry experience essential as castings are molded under three stationary types of sand slingers. Location, Ohio. Y-5396-C.

Graduate Mechanical Engineer for engineering publicity work. Company will consider recent graduate if he has good background in mechanical-engineering subjects and aptitude for writing accurately with good diction; however, engineer with experience preferred. Work consists of writing descriptive literature on air compressors, Diesel engines, and associated mechanism, making computations on performance, compiling data, making instruction drawings, and arranging other material for catalogs, instruction books, and the like. Applicant should forward application outlining qualifications, accompanied by letter in own handwriting applying for position. Location, East. Y-5827.

Engineer, under 35, to investigate book publishing plant to effect economy and cut costs. Salary, $200 month. Temporary. Location, East. Y-5843.

Production Engineer, 35–45, experienced in all phases of production for metal stampings, tubing, miscellaneous steel. Should also have background in machine-shop practice, particularly involving automatic screw machines, millers, etc. Salary, $300–$500 month. Location, Pacific Coast. Y-5845-C.

Designer in Charge, graduate mechanical engineer thoroughly experienced in design of special and automatic machines. Should also be thoroughly familiar with design of special dies for metal stampings. Salary, $65–$100 a week. Location, New York, N. Y. Y-5846.

Designer familiar with machine design and capable of designing and developing varying line of new equipment. Must have 15 to 20 years' experience in designing of medium-weight special machinery and parts and be thoroughly familiar with production methods and requirements. Should also be capable of dealing with engineering calculations necessary in formulating these designs. Salary, $200–$210 month. Location, Maryland. Y-5847.

Factory Manager, about 40, graduate mechanical engineer (physicist), with knowledge of scales or balances desirable but not essential. Salary, $5000 year. Location, East. Y-5849.

Designer, mechanical engineer, to lay out plant improvements, rearrangement of departments, reduction of methods and equipment; should also be able to design small and special equipment. Must have personality to impress department heads. Salary, $4000 year. Location, New York State. Y-5859.

Designer, graduate mechanical engineer, for research. High-grade man experienced in railway-car truck design. Should also have some experience in railroad engineering department. Location, New York State. Y-5865.

Machine Designers, graduate mechanical engineers, with at least four or five years' experience in design of special machinery for some basic industries such as paper, rubber, chemical, soap, oil, steel. Applicant should have some practical experience in shop work either in college or since graduation. Salary, $200–$275 a month. Location, Middle West. Y-5866-C.

Supervisors, 2; one experienced in machine-shop operations and familiar with the production of many small parts. Other applicant should be experienced in sheet-metal work. Salary, $250 a month. Location, South. Y-5870.

Chief Engineer, about 35 to 45, graduate mechanical engineer (physics), to design line of vacuum cleaners. Experience does not necessarily have to be mechanical experience. Will be required to supervise and organize work. Salary open. Location, East. Y-5885.

Graduate Mechanical Engineer, young, with four years or more of industrial experience in machining practice; familiarity with automatic machine tools desired. Should be above average in mathematical ability to deal with design problems of all kinds. Should have ability to handle correspondence and to write reports and technical articles. Should be able to meet people in all ranks of industry and have good judgment in shop problems. Apply by letter. Considerable traveling. Headquarters, New York, N. Y. Y-5886.

Development Engineers, 5 to 10 years out of college; sound and thorough technical education; with important background in mechanical engineering and training, as well as knowledge of the fundamentals of chemistry and electrical principles. Should be able to take over ideas worked out by research department and develop new and unique types of mechanical equipment and design. Must have creative mind and ability to design new things. Apply by letter giving education, training, experience; also attach photograph. Location, South. Y-5887.

Industrial Engineer, about 30, graduate engineer, to take up work covering time studies, incentive systems, on one-year contract. Immediate duty will be to install departmental budget controls. Applicant must have personal qualities to get along with men in plant. Salary, $400–$500 month. Location, South. Y-5890.

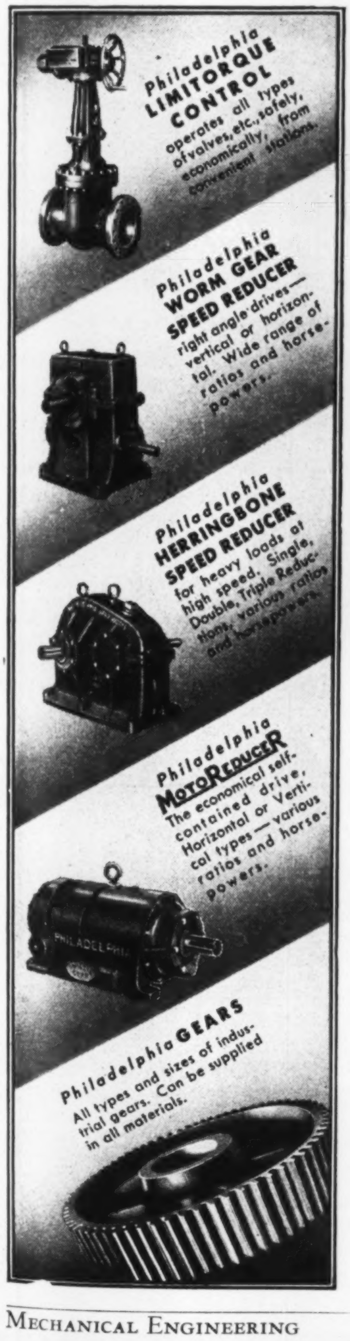
Salesman for industrial metal cleaner, to make contacts with railroad traction companies, etc. Salary, $200 month, plus $20 for car. Location, New York, N. Y. Y-5893.

Chief Executive and Administrative Engineer, preferably mechanical engineering graduate, to coordinate activities between engineering, sales, purchasing, design, and comptroller's office of large manufacturing company. Man who has been connected with refrigeration industry preferred. Salary, $10,000–$15,000 a year. Location, Middle West. Y-5903-C.

Mechanical Engineer. Must be graduate

(*A.S.M.E. News continued on page 578*)

"IT SEEMS NO TWO PLANTS HAVE JUST THE SAME POWER TRANSMISSION PROBLEMS."
"NO .. THAT'S WHY PHILADELPHIA MAKES ALL TYPES OF SPEED REDUCERS .. THE RIGHT UNIT FOR THE RIGHT JOB."



Philadelphia LIMITORQUE CONTROL operates all types of valves, etc., safely, economically, from convenient stations.

Philadelphia WORM GEAR SPEED REDUCER right angle drives—vertical or horizontal. Wide range of ratios and horsepowers.

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• It's a well known fact that no one remedy can cure all human ills and it's just as true no single type of speed reducer can best fill every power transmission requirement. That's the reason we make Philadelphia Units in ALL TYPES and that is why Philadelphia customers can be sure our recommendations are unbiased to any type and that the unit we suggest will, in our judgment, give the most efficient, most economical and most satisfactory service all around.

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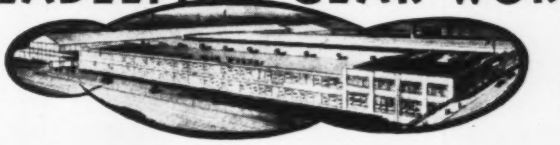

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